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National research on space debris, safety of nuclear-powered satellites and problems of collisions of sources with space debris

Note by the Secretariat

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I. Introduction

1. In its resolution 53/45, paragraph 31, of 3 December 1998, the General Assembly considered it essential that Member States pay more attention to the problem of collisions of space objects, including those with nuclear power sources, with space debris, and other aspects of space debris, and called for the continuation of national research on that question, for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris. To the extent possible, the Assembly considered that information thereon should be provided to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

2. The Secretary-General addressed a note verbale, dated 30 August 1999, to all Member States, inviting them to communicate to the Secretariat, by 31 October 1999, the information requested above, so that the Secretariat could prepare a report containing that information for submission to the Subcommittee at its thirty-seventh session.

3. The present document was prepared by the Secretariat on the basis of information received from Member States and international organizations as of 10 December 1999. Information received subsequent to that date will be included in addenda to the present document.

II. Replies from Member States

Cyprus

[Original: English]

Regarding the issue of space debris and the question of the use of nuclear power sources in outer space, the Government of Cyprus has the honour to inform the Secretary-General that it has no comments to offer.

Ireland

[Original: English]

Ireland recognizes the growing problem of space debris and the associated risk of collisions, and would support actions to research and promote appropriate standards for control and disposal of materials placed in space.

Thermoelectric nuclear power sources are used occasionally by various agencies, for example for deep-space missions where solar photo-electric energy is inadequate, and Ireland would support action to research and promote strict standards and safeguards for such power sources.

Israel

[Original: English]

Israel has no activity whatsoever using nuclear power sources in outer space.

Republic of Korea

[Original: English]

Regarding the issue of space debris, the Republic of Korea has suggested a "launcher's pay principle" whereby the advanced countries that are producers of space debris should be responsible for the debris in outer space. This is consistent with the current tendency in environmental policy on the ground. Countries that have put space debris in outer space such as France, the Russian Federation and the United States of America, should take the leading role in disposal of debris, establishing standards, and seeking mitigation measures. They also need to support developing countries to reduce the space debris in the future by establishing an international fund to support those activities.

The use of nuclear power sources should be limited strictly except for special missions such as deep-space missions. In such inevitable cases, safety design and standards need to be established. Those technologies need to be shared between the developed and developing countries to keep our Earth and outer space safe and clean.

The Netherlands

[Original: English]

As regards the identification of terrestrial processes and technical standards that might be relevant to nuclear power sources in outer space, the Netherlands does not undertake any activities in this field. It is therefore impossible for the Netherlands to further reflect on the factors that might distir guish nuclear power sources in outer space from terrestrial nuclear applications.

United Kingdom of Great Britain and Northern Ireland

[Original: English]

A. Introduction

The United Kingdom continues to play a key role in addressing the space-debris problem. This is achieved at the national level through the United Kingdom Space Debris Coordination Group and at international level through the Inter-Agency Space Debris Coordination Group (IADC) and the United Nations Committee on the Peaceful Uses of Outer Space. The British National Space Centre continues to coordinate the United Kingdom's involvement in these forums.

The most recent United Kingdom Coordination Group meeting took place in April 1999 at the Defence Evaluation and Research Agency (DERA). It was attended by all the major United Kingdom debris research groups from industry and academia, including: Century Dynamics, the United Kingdom Defence Evaluation and Research Agency, Fluid Gravity Engineering, the Ministry of Defence, Matra Marconi Space (MMS), and the Universities of Kent, London and Southampton. Presentations were given on a diverse range of subjects covering: activities at the previous IADC meeting in Toulouse; progress in developing debris tracking equipment; advances in, and results from, new debris/ meteoroid models; and research activities relating to debris shielding.

Internationally, the United Kingdom participated in a full meeting of the IADC in Toulouse in November 1998, and at a meeting of the IADC Steering Group in Vienna in July 1999.

During the past year, the United Kingdom has conducted the following space-debris research and development activities.

B. Measurement of the debris population

1. Debris detectors

Real-time detection in space offers valuable insight into the space-debris and meteoroid environment. The detection method typically utilizes the energy of an impacting particle to trigger a measurement and, consequently, destroy the physical entity of the particle. The Unit for Space Sciences and Astrophysics, University of Kent at Canterbury, has maintained progress on three flight opportunities for a space-debris detector known as DEBIE. A Finnish consortium is assisting in the first of these opportunities by providing for manufacture in readiness for flight on the European Space Agency (ESA) PROBA spacecraft, which is due for launch in mid-2000. The flight sensors are due at Kent for calibration in November 1999. On the second flight opportunity the DERA Space Technology Research Vehicle (STRV 1C satellite), Kent has calibrated the flight sensors and delivered all flight hardware in August and September 1999. All units have been integrated onto the spacecraft, and launch is scheduled for the first quarter of 2000. The final flight opportunity is on the International Space Station (ISS). The ESA Technology Exposure Facility will be launched in June 2002, with a flight duration of three years and subsequent return to Earth. Consequently, this will provide an opportunity for post-flight inspection of the retrieved surfaces.

Kent has also been exploring the use of a new detection technique, called the Aerogel Position Sensitive Impact Sensor (APSIS), which will combine real-time detection with retrieved sample analysis.[1] By measuring the position and time of the impact on a retrievable collector, post-flight scanning and residual analysis can provide chemical and physical data on the impactor. Furthermore, if combined with the velocity vector of the spacecraft at the instant of detection, it can yield the trajectory in the appropriate orbital reference frame. Results of system requirements analysis favour the deployment of APSIS as a large-area detector, which makes it an ideal candidate for ISS.

2. Analysis of returned surfaces

As with *in situ* detectors, the analysis of returned surfaces from space provides valuable data on the space environment. Most recently, Kent has analysed solar cells from one of the solar arrays on the Hubble Space Telescope, which was returned after 3.62 years

in space. Analytical scanning electron microscopy was used to successfully identify the origin of 23 out of 29 of the impact craters on the selected cells. The observed chemical classification of the impact residues, in terms of meteoroid to debris, corresponded well with flux model predictions. Additionally, the residue results have also been critically evaluated by comparing them with ground-based impact tests on solar cells using the Kent light gas gun (LGG). This has confirmed that similar textures and chemical effects are produced in the craters, thereby giving confidence in the results of the microscopy analysis. Various papers on this work have been presented at conferences and in respected journals.[2, 3]

C. Debris environment modelling

Modelling of the debris environment, its long-term evolution, and the potential risks it causes to possible future space systems continues to be a major activity among debris researchers in the United Kingdom. The effect of continually introducing new assets into near-Earth space, and therefore the consequences for the debris environment, is also a key research area.

1. Modelling of debris sources

One of the most difficult aspects of modelling the debris environment is to accurately model the populations of small-size debris (< 1 mm). Current models significantly under-predict the debris populations at those sizes. One of the main reasons is that the models do not include all of the sources of debris. For example, the generation of paint flakes from in-orbit spacecraft surfaces has not yet been considered. Research at Queen Mary and Westfield College, University of London, under funding and guidance from DERA, has however enabled the production mechanisms for microdebris to be investigated. A model of microdebris generation is being developed, which considers the effects of atomic oxygen, thermal cycling and ultraviolet radiation. Measurements have taken place experimentally to identify the role of each of these physical phenomena, and the issue of initial surface preparation and defects has been used to generate statistical distributions for the size of potential microdebris objects. Ultimately, it is intended that the derived model will be incorporated into debris environment and evolution models, such as the DERA Integrated Debris Evolution Suite (IDES), thereby eliminating one of the main causes of under-prediction.

2. Modelling the current debris environment in geosynchronous Earth orbit

Whereas models of the current debris environment in low-Earth orbit (LEO) are becoming quite thorough, at geostationary altitudes (i.e. in geosynchronous Earth orbit (GEO)) there is much more uncertainty. A consortium comprising Kent, DERA, the National Office for Aerospace Studies and Research (ONERA) (Toulouse), the Max Planck Institute (Heidelberg) and the University of Maryland has been awarded an ESA contract to extend modelling of space debris and other environmental factors from LEO to GEO. The work is ongoing and will be reported on next year.

3. Long-term evolution of the debris environment

The DERA IDES debris model has recently been enhanced and revalidated as measurement data on new sources of debris and new debris environments have become available. The model's reference epoch has been updated to 31 March 1998 owing to the integration of a new historical launch-related object database covering launches from 1957 to mid-1998 and the additional simulation of fragmentation events occurring since the model's previous reference epoch of 1 January 1996. IDES now includes a newly developed sodium-potassium liquid coolant droplet source model that has led to dramatic improvements in the accuracy of the model predictions for the centimetre-sized debris environment. The enhanced IDES debris model has been used extensively to study the long-term evolution of the LEO debris environment in detail, including the influence of LEO satellite constellations and debris-mitigation measures. Following late receipt of some test case data from the National Aeronautics and Space Administration (NASA) of the United States, the IDES model has provided the British National Space Centre (BNSC) with input to an international long-term LEO model comparison study being conducted within the IADC. The completion of this basic comparison study will pave the way for more sophisticated comparisons, based on a similar framework and common model input data. These more advanced IADC studies may lead to international consensus on important issues such as the effectiveness of different debris-mitigation measures as implemented by the general satellite population and by commercial satellite constellation systems.

The success of the DERA IDES model has led ESA and the European Space Operations Centre (ESOC) to issue a contract to develop a version of IDES for their uses. The new model, which is to be delivered to ESA in early 2000, is called Debris Environment Long Term Analysis (DELTA). DELTA will rely on an initial debris population derived by the ESA Meteoroid and Space Debris Terrestrial Environment Reference (MASTER) model, recently updated by the Technical University of Braunschweig, Germany. DELTA will provide long-term projections of the >1 mm LEO debris environment and associated mission collision risks over the next 100 years. Major advances within DELTA have been made in the speed and accuracy of long-term orbit propagation; the high resolution of the future launch traffic model; the breakdown of the model predictions by different debris source components; and the direct prediction of the collision cascading process. Overall, the ESA DELTA model should be state-of-the-art and offer more advanced capabilities than other models.

At Queen Mary and Westfield College, University of London, researchers have continued to develop their innovative Direct Simulation Monte Carlo (DSMC) debris model. It provides a statistical analysis capability to predict the long-term evolution of the orbital debris environment, with the aim of improving space vehicle risk assessment. The objective is achieved by assuming that debris can be modelled by employing sample particles to represent the real debris population. Based on standard particle kinetic theory, the debris collision probability is evaluated rigorously. The combination of a spacecraft break-up model, a collision probability model and a debris particle de-orbit aerodynamic drag model allows debris population growth to be predicted. The DSMC model has been validated by comparing predictions with results from the Long Duration Exposure Facility (LDEF) satellite's impact experiments. Simulations from the model have also been used to predict the number of Space Shuttle windows requiring replacement, and the predictions are compared with actual data. Recently, work has begun to expand the environment model to include natural micro-meteorites. The DSMC debris model research has been published in a major space journal.[4]

Research at the Department of Aerospace Engineering, University of Glasgow, has focused on investigating the long-term evolution of a large constellation of nanosatellites in Earth orbit using closed-form analytical methods. The work is of growing interest given that nanosatellites are seen as a low-cost means of enabling a diverse range of innovative mission applications. Future nanosatellite systems may comprise many thousands of satellites, each with a mass in the range 0.001 kg to 1 kg. It is likely that the satellites will have no active control, so environmental effects such as air drag will shape the evolution of the constellation. The modelling work at Glasgow aims to evolve the mean spatial density of a typical constellation under the action of air drag, while considering in-orbit satellite failures and the deposition of new satellites to replenish the constellation. One of the most interesting findings shows that, under certain circumstances, the nanosatellite number density will decrease with time, but its peak will become biased to higher altitudes. Estimates of the required rate of deposition of new nanosatellites to maintain the constellation can also be derived using the technique. The research is due to be published in a respected journal.[5]

4. Short-term debris risks to space assets

The University of Southampton actively undertakes short-term debris risk assessments of major space assets. Recently, these have included collision hazard analyses of a constellation of 800 satellites (based on the original Teledesic configuration) and of the new ISS. Both assessments used the space debris simulation (SDS) software model, which was developed at Southampton under contract to DERA. For the constellation risk assessment, two potentially threatening scenarios were considered: (a) fragmentation of one of the constellation satellites; and (b) a break-up of a constellation launch vehicle. It was found that the collision risk to the constellation is low in the short term. Of the scenarios examined, the collision-induced break-up of a constellation satellite posed the greatest threat to the system. For the ISS risk assessment, the threat from a fragmentation of an upper stage or spacecraft in a neighbouring orbit was considered. Based upon the case studies considered, impact probabilities in the short term that were due to ISS encounters with the fragmentation debris cloud were found to be up to four orders of magnitude higher than those due to the background debris population. The results of these studies have been published in a respected journal and reported at major international conferences.[6, 7]

D. Spacecraft debris protection

The protection of spacecraft from the impact of hypervelocity debris is another research area in which the United Kingdom is actively involved.

1. Hypervelocity impact testing

A consortium comprising MMS, DERA, Kent, and Fluid Gravity Engineering is nearing the end of a two-year ESA contract to investigate cost-effective debris shielding solutions for unmanned spacecraft. Because of the constraints placed on the design of typical spacecraft in terms of both costs and mass, there are a limited number of credible shielding options available. The consortium has proposed a new set of debris-shielding solutions that should improve the survivability of future spacecraft, including replacing the standard single-layer aluminium honeycomb structure, typical of many spacecraft, with a double layer, and adding layers of Beta cloth to multi-layer insulation thermal blankets

covering the satellite structure. Sample shields have been manufactured and subjected to a range of hypervelocity impacts using LGG. Results from these tests have enabled the derivation of ballistic limit equations for each new shield type. These equations ensure that the performance of the shields can be predicted when applied to a satellite. During the remainder of the contract period, a cost-risk benefit analysis will be performed to quantify the cost-effectiveness of the shielding solutions. Finally, guidelines will be produced to advise designers of spacecraft systems on the most appropriate choice and location of shielding for a particular spacecraft design.

2. Satellite survivability modelling

DERA has continued to develop an innovative software model called SHIELD. The purpose of SHIELD is to identify the optimum debris-protection strategy for a particular satellite mission. It will do so by using a genetic algorithm to automatically search through and evaluate many thousands of competing possibilities for the configuration of equipment inside a three-dimensional geometrical representation of the satellite body, together with the many choices and locations for applying shielding to the satellite. The evaluation process utilizes a newly formulated survivability metric to rapidly determine the effectiveness of each solution. One of the inputs to this metric is a Monte Carlo-generated distribution of penetrating debris impactors on the satellite body, which in turn has been derived from directional debris flux data generated by the IDES model of DERA. The metric is constructed in such a way that it can reveal whether critical items are sufficiently well-protected by neighbouring equipment and whether the benefits from adding shielding justify the extra cost and mass. In this way, the model can determine the best solution for providing maximum protection to critical equipment. It is envisaged that the model could ultimately become an additional engineering tool for use during the earliest phases of a satellite project when there is sufficient flexibility for design changes. Version 0.1 of SHIELD has just been completed and is now ready for validation. The work has been published as an invited paper at a major space conference, and in a respected British defence journal.[8, 9]

3. Hydrocode modelling

The design of improved bumper shields using novel materials such as Nextel and Kevlar is essential in order to minimize the impact risks to future long-life space missions, particularly those requiring a manned presence. It is therefore essential to characterize the response of these new materials to hypervelocity impact in order to ensure optimal shield design. By necessity, hydrocode software simulations are required to verify the performance of the shields at the velocities typical of orbital debris impacts (> 10 km/s). To do this, hydrocodes utilize material models under conditions of high pressure and strain. Material models have already been developed for aluminium, a standard material on a spacecraft, but not for Nextel and Kevlar. A British company, Century Dynamics, under contract to ESA, has been developing material models for these particular materials. The quality of the derived models has been demonstrated by comparing hydrocode simulations with impact tests. A paper describing the research has been presented at a major international symposium and was subsequently nominated for the best paper award.[10]

Century Dynamics has also invested significant effort in improving their own hydrocode software called Autodyn. Long-term research and development into a technique known as smooth particle hydrodynamics (SPH) is continuing through a combination of

internal investment and funding from the Ministry of Defence and DERA. Most notably, a three-dimensional SPH capability has now been implemented in Autodyn and validated. Autodyn is now becoming highly regarded throughout the world, with both ESA and NASA purchasing licences for large computer installations during the last year.

Notes

[1] J. A. M. McDonnell and others, "Aerogel position-sensitive impact sensor: capabilities for in-situ collection and sample return", preprint.

[2] G. A. Graham and others, "Hypervelocity impacts in low Earth orbit: cosmic dust versus space debris", *Advances in Space Research*, vol. 23, No. 1 (1999), pp. 95-100.

[3] G. A. Graham and others, "Natural and simulated hypervelocity impacts into solar cells", to be published in *International Journal of Impact Engineering*.

[4] L. Wang and J. P. W. Stark, "Direct simulation of space debris evolution", *Journal of Spacecraft and Rockets*, vol. 36, No. 1 (January-February 1999).

[5] C. R. McInnes, "A simple analytical model of the long term evolution of nanosatellite constellations", to be published in *Journal of Guidance, Control and Dynamics*.

[6] G. G. Swinerd, S. P. Barrows and R. Crowther, "Short-term debris risk to large satellite constellations", *Journal of Guidance, Control and Dynamics*, vol. 22, No. 2 (1999), pp. 291-295.

[7] G. G. Swinerd, S. P. Barrows and P. H. Stokes, "Short-term debris risk to the International Space Station arising from a spacecraft fragmentation", presented at the Forty-ninth International Astronautical Congress, held in Melbourne, Australia, 28 September-2 October 1998, paper No. IAA-98-IAA.6.4.04.

[8] P. H. Stokes and others, "Novel modelling solutions for debris risk reduction", *Advances in Space Research*, vol. 23, No. 1 (1999), pp. 231-241.

[9] P. H. Stokes and others, "Protecting satellites against orbital debris", *Journal of Defence Science*, vol. 4, No. 2 (1999), pp. 121-131.

[10] C. J. Hayhurst and others, "Development of material models for Nextel and Kevlar-epoxy for high pressures and strain rates", paper presented at the Hypervelocity Impact Symposium, held in Huntsville, Alabama, United States, in November 1998, paper No. 1044.

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Report on the United Nations/Spain Workshop on Space Technology for Emergency Aid/Search and Rescue Satellite-Aided Tracking System for Ships in Distress

(Maspalomas, Gran Canaria, Spain, 23-26 November 1999)

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Abbreviations

bps	bits per second
COSPAS	Russian acronym meaning space system for the search of vessels in distress
ELT	emergency locator transmitter (aeronautical distress beacons)
EPIRB	emergency position indicating radio beacon (maritime distress beacon)
GEOLUT	a ground receiving station in the COSPAS-SARSAT system that detects, processes and recovers the coded transmissions of 406 MHz emergency distress beacons and relays the appropriate information to an MCC
GEOSAR	geostationary Earth orbit search and rescue (satellite system at 406 MHz)
Hz	hertz
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
kHz	kilohertz
LEOLUT	a ground receiving station in the COSPAS-SARSAT LEOSAR system that detects, characterizes and locates emergency beacons and forwards the appropriate information to an MCC
LEOSAR	low Earth orbit search and rescue (satellite system in polar orbit)
LUT	local user terminal (COSPAS-SARSAT ground receiving station)
MCC	mission control centre of COSPAS-SARSAT
MHz	megahertz (radio frequency)
NOAA	National Oceanic and Atmospheric Administration (United States)
PLB	personal locator beacon (distress beacon used on land)
RCC	rescue coordination centre
SAR	search and rescue
SARP	search and rescue processor (406 MHz processor of the LEOSAR system)
SARR	search and rescue repeater (406/121.5 MHz repeater of the LEOSAR system)
SARSAT	search and rescue satellite-aided tracking
SPMCC	Spanish Mission Control Centre
SPOC	SAR point of contact
SRR	search and rescue region

I. Introduction

A. Background and objectives

1. The General Assembly, in its resolution 37/90 of 10 December 1982, decided that, in accordance with the recommendations of the second United Nations Conference on the Exploration and Peaceful Uses of Outer Space,[1] the United Nations Programme on Space Applications should assist the developing countries in establishing an autonomous technological base for the development and the use of space technology by promoting the growth of indigenous capabilities. The Committee on the Peaceful Uses of Outer Space, at its forty-first session, held in June 1998, endorsed the programme of workshops, training courses and seminars proposed for 1999 by the Expert on Space Applications. The General Assembly, in its resolution 53/45 of 3 December 1998, endorsed the United Nations Programme on Space Applications for 1999.

2. The present report contains a summary of the presentations and discussions of the United Nations/Spain Workshop on Space Technology for Emergency Aid/Search and Rescue Satellite-Aided Tracking System for Ships in Distress. The Workshop was organized as part of the 1999 activities of the Office for Outer Space Affairs of the Secretariat under the United Nations Programme on Space Applications.

3. The Spanish Mission Control Centre (SPMCC) of the International Satellite System for Search and Rescue (COSPAS-SARSAT) in Maspalomas is responsible for transmitting directly any alert signal received from any of the following 20 African countries: Benin, Cameroon, Cape Verde, Central African Republic, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone and Togo. All these countries can participate effectively in COSPAS-SARSAT life-saving programmes by investing in simple radio beacons whose alert signals can be identified, located and detected in time of danger and subsequently relayed to a rescue coordination centre. The absence of such a facility in many African countries has resulted in the loss of many lives that could have been saved, a situation that led to the organization of the Workshop.

4. The Workshop was organized to provide those countries within the footprint of the COSPAS-SARSAT station in Maspalomas with an opportunity to gain the necessary knowledge to enable them to lead their national authorities into action and to ensure that their respective countries participate in the COSPAS-SARSAT programme.

5. The present report has been prepared for consideration by the Committee on the Peaceful Uses of Outer Space at its forty-third session and by its Scientific and Technical Subcommittee at its thirty-seventh session in 2000. The participants will report to the appropriate authorities in their own countries.

B. Organization and programme of the Workshop

6. The United Nations, in cooperation with the National Institute for Aerospace Technology (INTA), SPMCC and the Spanish Ministry of Foreign Affairs, organized the Workshop to address the issue of search and rescue in the area covered by the Maspalomas station and possible operations in the concerned West African countries. The Workshop was held on 23-26 November 1999, at INTA in Maspalomas.

7. At the opening session of the Workshop, Julio Melian, former Director and Coordinator, INTA, José Ortiz Ruiz del Castillo, Director of the Centro Espacial de Canarias, and Juan Manuel Salaz, Ministry of Foreign Affairs of Spain, welcomed all participants on behalf of the Government of Spain and INTA. Viktor Kotelnikov, representing the Programme on Space Applications, welcomed all participants on behalf of the United Nations.

8. The Workshop was held in three different sessions, the first two of which focused on practical programmes and related operations of COSPAS-SARSAT. During the course of the Workshop, successful examples of the use of the COSPAS-SARSAT system were presented. Subsequent round-table discussions addressed the relationship between SPMCC in Maspalomas and the individual country's search and rescue point of contact.

9. The participants visited the Maspalomas tracking station installation and received a more elaborate explanation of the work carried out at the COSPAS-SARSAT operation room. During that visit, a demonstration was conducted with the activation of a 406 MHz radio beacon and the related location calculation by the local user terminals, with an accuracy that was better than 1 kilometre. Participants also visited the Centre

for Reception, Processing, Archiving and Dissemination of Earth Observation Data and Products (CREPAD), which is co-located at Maspalomas with the COSPAS-SARSAT station.

10. The Workshop exposed the participants to COSPAS-SARSAT operations, including the procedure for distribution of alert signals, once they are received at the Maspalomas station. Participants were also informed about major disaster-related Internet Web sites.

11. The participants of the Workshop also participated in a real search and rescue training exercise under the supervision of Rafael Sanchez Pons, General de Brigada de Aviación, on board a specialized search and rescue vessel.

C. Participants

12. A total of 15 participants from 5 African countries (Cape Verde, Ghana, Mauritania, Nigeria and Togo), Spain and the Office for Outer Space Affairs attended the Workshop. Participants were professionals at the level of director and senior programme managers associated with or responsible for safety issues in connection with operating airlines of their country; the country's maritime agency and port authorities; the geological survey and land survey departments; the telecommunications industry; or the national disaster management board or bureau.

13. The Government of Spain (through INTA and the Ministry of Foreign Affairs) provided room and board for all the invited participants and was responsible for all the local logistics of the Workshop. The United Nations provided funds to cover the travel and en route expenses of the participants.

II. Observations and recommendations of the Workshop

A. Observations

14. Most of the African countries do not presently have a well-defined or designated Search and Rescue Satellite-Aided Tracking System (SARSAT) point of contact or mission control centre (MCC).

15. Most alert messages received by SPMCC are not received by the country concerned owing to the absence of a well-defined SARSAT point of contact (SPOC).

16. Most of the participating user countries do not possess the necessary communications equipment in their SPOC.

B. Recommendations

17. Having considered the problems arising from the ineffective and/or inefficient implementation of the COSPAS-SARSAT programme through SPOCs under the SPMCC service area, the Workshop made the following recommendations:

(a) Participants should endeavour to advise their countries on the need for a well-defined point of contact;

(b) In order to ensure cost-effectiveness, various country rescue coordination centres (RCCs) should immediately provide SPMCC with their telephone and fax numbers, e-mail, Inmarsat or cellular phone numbers etc. for immediate alert messages from SPMCC;

(c) User providers such as SPOCs should endeavour to send feedbacks to SPMCC whenever alert messages (real or false) are sent to them;

(d) Delegates should sensitize and encourage their Governments to participate in the COSPAS-SARSAT programme to save lives;

(e) Regular regional workshops or seminars on the COSPAS-SARSAT programme should be organized;

(f) Communication exercises should be carried out on a regular basis to check the connections between SPMCC and the SPOCs in its service area (SPMCC recommendation);

(g) Countries within the SPMCC service area wishing to participate as user State in the COSPAS-SARSAT programme should comply with the corresponding requirements;

(h) Participating countries should introduce the use of radio beacons and maintain a register on them;

(i) User providers such as SPOCs should take urgent steps to eliminate interference reported by SPMCC (SPMCC request);

(j) Countries wishing to be informed of any COSPAS-SARSAT alert message concerning vessels, aircraft etc. from their own countries (the country code is included in the 406 MHz radio beacons) in an alert situation anywhere around the world must send a letter

to SPMCC requesting the Notification of Country Register (NOCR);

(k) When a NOCR is received from SPMCC, a country should report all information available from its beacon register concerning the vessel, aircraft etc. involved to SPMCC as soon as possible. SPMCC will then pass on all information to the MCC responsible within the area of the distress.

III. Summary of the Workshop

A. Spanish Mission Control Centre

18. The Spanish Mission Control Centre, located at the INTA satellite tracking station in Maspalomas, Gran Canaria, Spain, is one of the 30 ground receiving stations of the COSPAS-SARSAT global network. The station was established by the Government of Spain in 1993. In addition to COSPAS-SARSAT operations, it provides tracking, telemetry and control operations for Spain's MINISAT-01, serves as a back-up tracking, telemetry and control station for the Meteosat Second Generation (MSG) satellite of the European Organization for the Exploration of Meteorological Satellites (EUMETSAT), supports the Japanese ETS-VII satellite and acquires Earth resource data from the Land Remote Sensing Satellite (LANDSAT), the Satellite pour l'observation de la Terre (SPOT), the European remote sensing satellites (ERS-1 and -2), satellites of the National Oceanic and Atmospheric Administration (NOAA) of the United States of America and the Indian Remote Sensing satellite (IRS).

B. COSPAS-SARSAT system

19. The COSPAS-SARSAT is a humanitarian search and rescue programme that uses satellite technology to locate vehicles in distress anywhere on the globe, whether on land, sea or in the air. The COSPAS-SARSAT system rapidly locates signals from distress beacons and sends an immediate alert to rescue coordination centres. With the aid of this system, 9,204 lives have been saved worldwide (as of 8 November 1999) since it became operational in 1982.

20. COSPAS-SARSAT satellites were primarily designed to detect beacons transmitting at 406.025 MHz. They have, however, the capability to detect signals from the large number of first-generation 121.5 MHz beacons that are still operational worldwide. Additionally, the SARSAT (but not the space system for the search of vessels in distress (COSPAS)) satellites were designed to monitor the military distress frequency of 243.0 MHz of the North Atlantic Treaty Organization (NATO).

21. Originally based on a constellation of low polar orbiting satellites, since 1996 the system has been complemented by geostationary relay satellites. Designed to operate with four satellites, the system currenly includes:

(a) Four American SARSAT satellites. These NOAA platforms, orbiting at an altitude of 850 km with a 98 degree inclination angle, carry a search and rescue payload of Canadian and French instruments (121.5 MHz and 406 MHz respectively);

(b) Three Russian COSPAS satellites. These Nadezda platforms, orbiting at an altitude of 1,000 km with a 98 degree inclination angle, fly Russian instruments.

22. In 1994, 406 MHz transponders were installed on several geostationary satellites to complement the COSPAS-SARSAT constellation for faster signal detection. The Indian Ocean is currently covered by the Indian telecommunications satellite INSAT-2A, the Atlantic Ocean by the American GOES-8 satellite, and the Pacific Ocean by a GOES-9 satellite. Europe and Africa will be covered as of the year 2000 by a transponder to be installed by the European Space Agency (ESA) on the second generation of Meteosat geostationary satellites.

23. The first second-generation instruments of the SARSAT system were installed on the American NOAA-K satellite launched on 13 May 1998, which was designed to collect a larger range of data than its predecessors.

24. The year 1999 was marked by the decision to start developing the third generation of SARSAT instruments to be installed on the future American NOAA and satellites of EUMETSAT.

25. Continuity of service of COSPAS-SARSAT systems is guaranteed to at least the year 2010. As part of the COSPAS-SARSAT 3 Programme, scheduled for development up to the year 2003, various agencies are working on the improvement of the operational search and rescue system.

26. In each of the world's service areas, there is one MCC to which all the ground receiving stations in the service area send the data from each satellite pass. All new

events are sent to an RCC within a given service area or they are sent to the MCC of the service area in which the event is located.

27. With the development of the system, more emergency beacons became available on the market. Aeronautical distress beacons continued to operate exclusively at 121.5 MHz, but maritime beacons were being built that operated at 406 MHz. Maritime search and rescue specialists immediately realized the benefits of 406 MHz beacons and, in 1990, took steps to bring them into widespread use. As a result, today there are over 33,000 maritime distress beacons in the NOAA 406 MHz Registration Database.

28. The COSPAS-SARSAT organization also continued to grow. The four original member countries (Canada, France, the former Union of Soviet Socialist Republics and the United States) have now been joined by 27 other countries and organizations that operate 35 ground stations and 19 MCC worldwide. COSPAS-SARSAT continues to be a model of international cooperation.

1. Satellite configuration

29. The COSPAS-SARSAT satellite constellation is composed of search and rescue satellites in low Earth orbit (LEOSAR) and geostationary orbit (GEOSAR).

30. The nominal system configuration of the LEOSAR satellite constellation is four satellites: two COSPAS and two SARSAT. The Russian Federation supplies two COSPAS satellites placed in near-polar orbits at 1,000 km altitude and equipped with search and rescue (SAR) instrumentation at 121.5 MHz and 406 MHz. The United States supplies two NOAA meteorological satellites placed in sun-synchronous, near-polar orbits at about 850 km altitude and equipped with SAR instrumentation at 121.5 MHz and 406 MHz provided by Canada and France.

31. Each satellite makes a complete orbit of the earth around the poles in about 100 minutes, travelling at a velocity of 7 km per second. The satellite views a "swath" of the Earth's surface of approximately 6,000 km wide as it circles the globe, having an instantaneous field of view about the size of a continent. When viewed from the Earth, the satellite crosses the sky in about 15 minutes, depending on the maximum elevation angle of the particular pass.

32. The current GEOSAR constellation is composed of two satellites provided by the United States, referred to as GOES East (GOES E) and GOES West (GOES W), and one satellite provided by India (INSAT-2A).

2. Mission control centres

33. MCCs have been set up in most countries operating at least one ground receiving station, which is called a local user terminal (LUT). Their main functions are: (a) to collect, store and sort the data from LUTs and other MCCs; (b) to provide data exchange within the COSPAS-SARSAT system; and (c) to distribute alert and location data to associated RCCs or SPOCs. Most of the data received by MCCs fall into two general categories: alert data and system information.

34. Alert data is the generic term for COSPAS-SARSAT 406 MHz and 121.5 MHz data received from distress beacons. For 406 MHz beacons, alert data comprise the beacon location and the coded information.

35. System information is used primarily to keep the COSPAS-SARSAT system operating at peak effectiveness and to provide users with accurate and timely alert data. It consists of satellite ephemeris (information that allows the satellite position to be determined) and time calibration data used to determine beacon locations, the current status of the space and ground segments and coordination messages required to operate the COSPAS-SARSAT system.

36. All MCCs in the system are interconnected through appropriate networks for the distribution of system information and alert data. To ensure the reliability and integrity of data distribution, COSPAS-SARSAT has developed MCC performance specifications and MCC commissioning procedures. Reports on MCC operations are provided by MCC operators on an annual basis. Worldwide exercises are performed from time to time to check the operational status and performance of all LUTs and MCCs and data exchange procedures.

3. Ground receiving stations: local user terminals

37. There are two types of LUTs in the COSPAS-SARSAT system, those that are designed to operate with the LEOSAR satellite constellation are referred to as LEOLUTs, and those that operate with the GEOSAR satellite constellation are referred to as GEOLUTs.

38. LEOLUT and GEOLUT operators are expected to provide the SAR community with reliable alert and location data, without restrictions on use and distribution of the information. The COSPAS-SARSAT parties providing and operating the space segment supply LEOLUT and GEOLUT operators with system data required to operate their LUTs. To ensure that data

provided by LUTs are reliable and can be used by the SAR community on an operational basis, COSPAS-SARSAT has developed LUT performance specifications and procedures.

39. The configuration and capabilities of each LEOLUT may vary to meet the specific requirements of participating countries, but the downlink signal formats of COSPAS and SARSAT LEOSAR spacecraft ensure interoperability between the various spacecraft and all LEOLUTs meeting COSPAS-SARSAT specifications.

40. The capability of a LEOLUT is determined, for the most part, by the LEOSAR satellite channels it was designed to process. Data from a possible four channels may, depending upon the specific satellite being tracked, be available for processing. Some satellites support all the channels described below and some support only a limited set of them, as follows:

(a) The 406 MHz Search and Rescue Processor (SARP) satellite channel transmits received 406 MHz beacon data that has already been partially processed by the satellite to determine the identification, time of transmission and frequency for each distress beacon transmission burst. Because of the onboard memory capability of the SARP channel, it provides global (yet not continuous) coverage for distress beacons that operate at 406 MHz;

(b) The 406 MHz Search and Rescue Repeater (SARR) channel receives 406 MHz beacon transmission bursts and immediately retransmits them on the satellite downlink. Since there is no memory associated with the repeater channel, this type of processing supports only local mode coverage (i.e. the distress beacon and the LEOLUT must be simultaneously within the view of the satellite for a period of time). Furthermore, since the satellite does not process the data, all the processing is performed by the LEOLUT;

(c) The 121.5 MHz and 243 MHz SARR channels operate in a fashion similar to the 406 MHz SARR channel; however, 121.5/243 MHz beacons do not include identification information.

41. For the 121.5 MHz, 243 MHz and 406 MHz signals received via their respective SARR channel, each transmission is detected and its Doppler frequency shift is calculated. A beacon position is then determined using these data. In the case of 406 MHz distress beacons, the LUT is also able to provide identification information associated with the beacon.

42. Processing the SARP channel 2.4 Kbps data (i.e. those generated from 406 MHz transmissions) is relatively straightforward since the Doppler frequency is measured and time-tagged onboard the spacecraft. All 406 MHz data received from the satellite memory on each pass can be processed within a few minutes of pass completion. In order to improve location accuracy, a correction of the satellite ephemeris is produced each time a LUT receives a satellite signal. The downlink carrier is monitored to provide a Doppler signal using the LUT location as a reference, or highly stable 406 MHz calibration beacons at accurately known locations are used to update the ephemeris data.

43. GEOLUTs are ground receiving stations in the COSPAS-SARSAT system that receive and process 406 MHz distress beacon signals that have been relayed by a COSPAS-SARSAT geostationary search and rescue satellite. Owing to the extremely large continuous coverage footprint provided by each geostationary satellite, GEOLUTs are able to produce near instantaneous alerting over extremely large areas. Owing to the fact that the satellite remains stationary with respect to distress beacons, GEOLUTs are not able to determine beacon locations using Doppler processing techniques. However, new types of 406 MHz beacons are available that allow for the encoding of position data in the transmitted 406 MHz message, thus providing for quasi-real-time alerting with position information via the GEOSAR system.

4. COSPAS-SARSAT radio beacon

44. There are three types of radio beacon: aviation emergency locator transmitters (ELTs), maritime emergency position indicating radio beacons (EPIRBs) and personal locator beacons (PLBs). The beacons transmit signals that are detected by COSPAS-SARSAT polar-orbiting spacecraft equipped with suitable receivers, and the signals are then relayed to COSPAS-SARSAT local user terminals, which process the signals to determine the location of the radio beacon that is transmitting the signals. Alerts are then relayed, together with location data, via an MCC either to another MCC or to the appropriate SAR point of contact or RCC.

45. The beacon is the weakest link in the COSPAS-SARSAT system. It is susceptible to damage upon impact, it can also be submerged in water or it may not have been mounted properly. Sometimes the beacon operates for only a short time before it is consumed by fire or it sinks.

46. The 406 MHz beacon signal has a greater chance of being detected in such instances because only 50 seconds are needed to be potentially detected by the GEOSAR system. The 121.5/243 MHz beacon has only a 20 per cent chance of having a satellite overhead; if it fortunately happens to be in this situation, it must operate a minimum of four minutes for an accurate location to be possible.

47. It is estimated that, worldwide, there were about 156,000 406 MHz beacons at the beginning of 1998 and that there are currently about 600,000 121.5 MHz beacons. The 406 MHz ELTs currently cost about $2,800 and 121.5 MHz ELTs cost less than $500, which is the greatest advantage of 121.5 MHz ELTs. Most of the 121.5 MHz beacons are used aboard aircraft, and they are required to meet national specifications based on standards of the International Civil Aviation Organization (ICAO). The 121.5 MHz system operates in local mode only. The overall coverage provided by the COSPAS-SARSAT system in local mode is determined by the number and positions of LUTs, each covering an area with a radius of approximately 2,500 km.

48. Of all alarm signals registered for all beacons, 90 per cent are false ones, which is very costly. The 406 MHz beacon has a high false alarm rate, but 99 per cent are solved by a telephone call. False alarms of 121.5/243 MHz beacons can interfere with real distress alarms from people in need of assistance.

49. There now exists a new 406 MHz beacon that can be plugged into a global positioning system (GPS) terminal; when activated, the GPS signal is transmitted to a GEOSAR and forwarded to an MCC. RCCs then know who is in distress and where they are located within minutes, rather than within hours, as in the case of the 121.5/243 MHz beacon.

50. Equipment required to home in on 406 MHz is still under development and is difficult to use on aircraft because the signal only pulses every 50 seconds. To counter the problem, many beacons also contain the low-powered 121.5 MHz frequency which is much easier to home in on when close to the signal (at a distance of approximately 10 km).

51. A recent study has shown that the average response time for 406 MHz beacons is about 46 minutes owing to the GEOSAR system. Once a beacon is activated, the geostationary satellite detects it immediately. Within a couple of minutes, an MCC operator who controls that beacon service area has the alert. Accordingly, the operator sends the registration information to the appropriate RCC and an immediate investigation ensues. Although no position is transmitted, the registration data can provide enough information to initiate a rescue, and the position is forwarded to the en-route rescue operation once it arrives.

52. The 406 MHz beacons have many advantages over the conventional 121.5 MHz ones. When a 406 MHz beacon is activated, it transmits a coded digital signal to the satellite. The code includes the beacon's unique identification, the country in which it is registered (numeric code) and the type of beacon (ELT, EPIRB, PLB) and it may include the method of activation (manual or automatic) and location information (second-generation beacons only).

53. The 121/243 MHz beacon can not be detected with a geostationary system because it does not have a unique identifier. The 46-minute response time advantage becomes even larger when compared to the response time of the 121.5/243 MHz beacon because a confirming source is usually needed prior to investigation.

54. A GEOSAR satellite usually notifies MCC within minutes of activation. Upon notification of an active 406 MHz beacon, MCC uses the beacon code to retrieve owner information from a database and forwards it to the appropriate RCC or, in the case of a PLB, to the designated authority. The database includes the name or call sign of the vessel or aircraft, a description of the vessel, the company or individual who owns the beacon, a 24-hour contact name and phone number, and other pertinent data that might be of use to SAR personnel.

55. The 121.5/243.0 MHz ELTs do not generally have such a capability. A few 121.5 MHz ELTs have been built with the aircraft call sign encoded within the signal. LEO satellites are subjected to multiple sources of spurious noise within the 121.5 and 243.0 MHz bands. The noise may be produced by electrical equipment or radio signals that interfere on the emergency frequencies.

56. As a result, a vast quantity of positions produced by LEO may have absolutely nothing to do with an active ELT. Compounding the problem is a limitation within the system. LEO satellites can determine a position perpendicular to its track, at a distance away from its path over the surface of the Earth; unfortunately, the equipment can not determine whether the source is to the left or to the right, thus two possible positions are produced.

57. Data from a subsequent satellite pass is processed by MCC software; if a position from the pass matches the original position, within designated parameters, a

"confirmed ELT" position is produced. A LEO satellite provides very accurate location data through the next LUT that tracks that satellite, but this may occur after a considerable time period, thus delaying SAR action. RCCs will begin taking action on a single position if other corroborating evidence is received, such as a report that an aircraft is known to be missing in the area, or if aircraft report of hearing an ELT on 121.5 MHz.

5. 406 MHz GEOSAR system

58. Over the past few years, COSPAS-SARSAT has been experimenting with 406 MHz receivers on geostationary Earth orbiting (GEO) satellites. The experiments have proven the capability of GEOSAR to provide immediate alerting and identification of 406 MHz beacons. GEO satellites are not able to use Doppler location processing since they have no relative motion between them and the emergency beacons.

59. Therefore, they are not able to determine a location for a beacon. They can, however, provide immediate alerts. This is a valuable tool for SAR personnel, since it allows them to begin their initial verification of the alert using the beacon registration database. The process often yields a general location of the vessel or aircraft in distress, and SAR assets can be readied or dispatched to that general area. Ideally, a SARSAT or COSPAS polar-orbiting satellite will overfly the beacon within the next hour and calculate a Doppler location, which will be forwarded to the SAR personnel who may already be en route.

60. Since every few minutes saved in reaching the scene of distress amounts to an increased chance of survival, the early warning capability of GEOSAR provides a valuable tool to increase the effectiveness of the COSPAS-SARSAT system and, ultimately, save more lives. It only works, however, if the beacon is registered.

61. The next logical step in utilizing the immediate alert capabilities of GEOSAR is to give the satellites some way of determining not only the identification but also the location of a distress beacon activation. This would provide immediate alerting and locating, something COSPAS-SARSAT has been in need of from its inception.

62. Specially made emergency beacons determine their location using GPS. The location is then encoded into the signal that is transmitted by the beacon. When the signal is received by an MCC, it is treated much the same way as one received from SARSAT and COSPAS satellites.

63. An MCC determines which RCC should respond and immediately transmits a message to that RCC. Thus, as long as an EPIRB is within view of a satellite (basically anywhere from 70 degrees north to 70 degrees south), a distress message reaches rescue personnel immediately. Since they know the exact location and identification of the EPIRB, the response will be extremely quick.

6. Discontinuation of 121.5 MHz service

64. The international COSPAS-SARSAT programme has announced that it will terminate satellite processing of distress signals from 121.5 and 243 MHz emergency beacons. Although the use of emergency beacons at these frequencies is not under the purview of the COSPAS-SARSAT programme, mariners, aviators and other persons will have to switch to emergency beacons operating at 406 MHz in order to be detected by satellites.

65. The COSPAS-SARSAT programme is currently working on the details, including the time-frame, of the termination of 121.5 and 243 MHz satellite alerting services. While no effective date has been set for this action, it is expected to occur far enough in the future to avoid a crisis situation for persons now using such beacons.

66. Guidance from the International Maritime Organization (IMO) and ICAO influenced the COSPAS-SARSAT programme's decision. These two specialized agencies of the Untied Nations system are responsible for regulating the safety of ships and aircraft, respectively, in international transit, and handle international standards and plans for maritime and aeronautical search and rescue. Over 180 countries are members of IMO and ICAO.

67. The high number of 121.5 MHz false alerts that inundate SAR authorities is another major factor influencing the decision to stop satellite processing. False alerts have an adverse impact on the effectiveness of life-saving services. While 406 MHz beacons cost more, they provide search and rescue agencies with the more reliable and complete information that they need to do their job more efficiently and effectively.

7. Year 2000 compliance

68. COSPAS-SARSAT has implemented a comprehensive programme to ensure the system's compatibility with all aspects of the year 2000 rollover. Current and future COSPAS-SARSAT satellite

constellations (both low-Earth orbit and geostationary segments) are now believed to be year 2000 compliant.

69. Furthermore, administrations that provide the ground segment components of the system have implemented programmes to achieve year 2000 compliance of the system components for which they are responsible. Moreover, the COSPAS-SARSAT Council has emphasized to responsible administrations the importance of ensuring that nationally approved 406 MHz beacons are year 2000 compliant. In addition, COSPAS-SARSAT has also contacted all manufacturers of COSPAS-SARSAT type approved beacons and received their confirmation that their approved beacons are year 2000 compliant.

70. COSPAS-SARSAT makes use of commercial communications systems to distribute distress alert information to the COSPAS-SARSAT ground-segment operations and to organizations responsible for handling distress alerts. COSPAS-SARSAT participants have made efforts to obtain confirmation from the providers of commercial services that they will be year 2000 compliant.

71. As COSPAS-SARSAT does not control the commercial communications systems however, assurances cannot be provided that the distribution of COSPAS-SARSAT distress alerts will not be affected. Thus, COSPAS-SARSAT participants have developed, to the extent feasible, contingency plans that will be implemented if communication difficulties arise as a result of year 2000 problems.

Notes

[1] See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-21 August 1982* (A/CONF.101/10 and Corr.1 and 2), part one, para. 430.

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Report on the United Nations/International Astronautical Federation Workshop on Space: an Integral Part of Sustainable Development

(Enschede, the Netherlands, 30 September–3 October 1999)

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I. Introduction

A. Background and objectives

1. The General Assembly, in its resolution 37/90 of 10 December 1982, decided that, in accordance with the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space,[1] the United Nations Programme on Space Applications should assist the developing countries in establishing an autonomous technological base for the development and use of space technology by promoting the growth of indigenous capabilities. The Committee on the Peaceful Uses of Outer Space, at its forty-first session, held in June 1998, endorsed the programme of workshops, training courses and seminars proposed for 1999 by the Expert on Space Applications.[2] The General Assembly, in its resolution 53/45 of 3 December 1998, endorsed the United Nations Programme on Space Applications for 1999.

2. The present report contains a summary of the presentations and discussions of the United Nations/International Astronautical Federation Workshop on Space: An Integral Part of Sustainable Development. The Workshop was organized as part of the 1999 activities of the Office for Outer Space Affairs of the Secretariat under the United Nations Programme on Space Applications. The Workshop was co-sponsored by the European Space Agency (ESA), the Centre national d'études spatiales (CNES) of France, Station 12® (the Netherlands) and the International Astronautical Federation (IAF). It was the ninth workshop in this series, and was held in Enschede, the Netherlands, in conjunction with the fiftieth Congress of IAF held in Amsterdam. Organizational and programme support was provided locally by the International Institute for Aerospace Survey and Earth Sciences (ITC).

3. Presentations at the eight previous United Nations/IAF workshops held from 1991 to 1998 in Australia, Austria, Canada, China, Israel, Italy, Norway and the United States of America have demonstrated that space technology can provide essential information and decision-making criteria in support of sustainable development. Data acquired by Earth observation satellites can be used for a broad range of applications, including natural resources management, environmental monitoring, and disaster warning and mitigation. Telecommunication satellites link rural and remote areas to the global telecommunications infrastructure, a pre-condition for sound economic, social and cultural development in the information age. They contribute to enable developing countries to quickly catch up with the industrialized nations and to become equal partners in economic and social development activities.

4. Over the past few years certain issues have been identified that require special attention in order to ensure the successful implementation of space technology, especially in countries with little prior experience in space technology applications. One major issue is the funding of pilot projects and the operational projects resulting from such pilot projects. The high degree of specialization and discipline-specific isolation of experts on space technology applications within their own fields in some countries may prevent them from cooperating in interdisciplinary projects and therefore may also be a barrier for the implementation of space technology applications to support and enhance existing development projects. One result is the lack of convincing cost-benefit studies that would encourage potential investor organizations to support the operational use of space technology applications by providing funds.

5. It has been recognized that implementing institutions should make efforts to convince decision makers of the benefits of space technology in order to gain the political and financial support needed for establishing an infrastructure and for educating and training a skilled user-base to secure the continuity and maintenance of operational systems. Many implementing institutions, however, are headed by scientists and technology specialists who excel in developing new methods for extracting information from remote sensing imagery but who often lack the experience to approach and lobby with decision makers.

6. National policy plans supported by policy makers and decision makers and the efficient coordination between space technology and user organizations are necessary to overcome existing political, institutional and operational constraints. Operational constraints relating to, for example, availability, accessibility, affordability, autonomy and timeliness issues have been repeatedly reported as being factors that inhibit operational use.

7. The Workshop addressed those issues and discussed how the use of space technologies could become part of an agenda for sustainable development. Special sessions and working group meetings focused on the funding of space-assisted development projects and on space technology applications for water resources management and forestry. The Workshop also allowed experts in space technology applications, policy makers, decision makers and

representatives of space industries from developing and industrialized countries to exchange experience in using space techniques for development purposes. The Workshop therefore provided a forum to discuss opportunities for increased regional or international cooperation among developing countries or between developing and industrialized countries.

8. The participants were fully briefed about the objectives and outcome of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), which was held in Vienna from 19 to 30 July 1999. Possible follow-up activities in line with the recommendations of UNISPACE III, as summarized in The Space Millennium: Vienna Declaration on Space and Human Development,[3] were discussed.

9. The present report covers the background and the objectives of the Workshop as well as the presentations made, the discussions held and the observations made and conclusions reached by the participants. It has been prepared for consideration by the Committee on the Peaceful Uses of Outer Space at its forty-third session and by its Scientific and Technical Subcommittee at its thirty-seventh session in 2000. The participants will report to the appropriate authorities in their own countries. The proceedings of the workshop, including a detailed address list of all participants, will be made available through the Office in due course.

B. Programme of the Workshop

10. During the course of the Workshop, successful examples of the use of space technology in applications for water resources and forestry management were presented. The Workshop was structured around seven sessions, in which 25 invited papers were presented. There was an extensive exchange of information, comments, recommendations and suggestions. In addition, 15 presentations by participants from developing countries provided an insight into the status of space technology applications in their respective countries.

11. A special panel was established, prior to the Workshop, to review the papers that would be presented and prepare draft recommendations of the Workshop for consideration by the participants. The review panel included senior space experts from the Kuala Lumpur Regional Centre for Forest Management of Malaysia, the Department of Forest Research and Survey of Nepal, the International Water Management Institute (IWMI), with headquarters in Sri Lanka, and the National Remote Sensing Center of the Sudan. The work of the panel was guided by an expert from the Food and Agricultural Organization of the United Nations (FAO). The afternoon sessions concluded with presentations by the review panel, followed by an open exchange of views.

12. National and transnational space projects and programmes were discussed, and possibilities were suggested for increased scientific and technical cooperation between developed and developing countries, as well as among the developing countries themselves.

13. Representatives of ITC and the National Aerospace Laboratory (NLR) of the Netherlands provided extensive organizational and programme support.

C. Participants

14. The United Nations, on behalf of the co-sponsors, invited developing countries to nominate candidates for participation in the Workshop. Selected participants were required to have university degrees in remote sensing, communications, engineering, physics, biological or medical sciences and preferably be involved in projects related to water and forestry resources management. In addition, participants were selected on the basis of their working experience in programmes, projects or enterprises in which space technology is or could be used. The participation of specialists at a decision-making level from both national and international entities was specifically encouraged.

15. Funds allocated by the Government of the Netherlands, the United Nations, ESA, CNES, Station 12® and IAF for the organization of the Workshop were used to cover international air travel and per diem expenses of 32 speakers and participants from developing countries. The co-sponsors also covered the cost of registration fees for participants from developing countries to participate in the fiftieth IAF Congress, which was opened immediately following the United Nations/IAF Workshop, thus enabling the participants to engage in discussions with their colleagues in one of the more important international space events.

16. The Workshop was attended by close to 100 individuals, including participants from Austria, Belgium, Brazil, China, Egypt, France, Ghana, India, Indonesia, Iran (Islamic Republic of), Italy, Japan, Kenya,

Malaysia, Mongolia, Morocco, Nepal, the Netherlands, Nigeria, Pakistan, Sri Lanka, the Sudan, the Syrian Arab Republic, Thailand, Turkey, the United Kingdom of Great Britain and Northern Ireland, the United Republic of Tanzania, the United States of America and Uzbekistan.

17. Presentations were made by representatives of the Office for Outer Space Affairs, the European Organization for Exploitation of Meteorological Satellites (EUMETSAT) on behalf of the Committee on Earth Observation Satellites (CEOS), the Arthur C. Clarke Institute of Modern Technologies of Sri Lanka, NLR, the Space and Upper Atmosphere Research Commission (SUPARCO) of Pakistan, the National Institute for Space Research (INPE) of Brazil, the Royal Centre for Remote Sensing (CRTS) of Morocco, the Indian Space Research Organization (ISRO), the National Aeronautics and Space Administration (NASA) of the United States, WMI, FAO, the African Development Bank (ADB), the World Bank, the Forest Survey of India, the General Organization of Remote Sensing (GORS) of the Syrian Arab Republic, the National Remote Sensing Agency (NRSA) of India, the Ministry of Hydrological and Electric Power of China, ITC, the Ministry of Soil Conservation of Nepal, the Tanzania Natural Resources Information Centre, and the Indonesian Space Agency (LAPAN).

18. Presentations were also made by representatives from private industry, including the following: ARGOS/CLS (France), Station 12® (the Netherlands), BRAZSAT (Brazil), Surrey Satellite Technology Ltd. (United Kingdom).

II. Observations based on the presentations and recommended actions

19. The Workshop focused on the themes "forest resources management" and "water resources management" and concentrated on defining impediments that affected the use of space technology for sustainable development and on proposing solutions. The discussions of the Workshop sessions were continuously reviewed by the review panel (see paragraph 12). Presentations by the World Bank and the African Development Bank, raised participants' awareness of possibilities for the funding of space applications projects.

20. The participants formulated the results of the Workshop, based on a questionnaire that was derived from the technical and country presentations, the sessions of the review panel and informal discussions. The observations and recommendations contained in the written responses are presented below.

21. There is, depending on the development status of a country, a real and substantial need for capacity building in the form of strengthening institutions, developing technological infrastructure and providing continuous education and training through national and international donor support. Networking among centres of excellence, universities and government institutions were considered essential for addressing this need.

22. Government, private sector and public awareness about the values of supporting economic and social developments using space technology need to be raised on a continuous basis.

23. Remote sensing, geographic information systems (GIS) and global positioning systems (GPS) applications need to be developed through a problem-oriented, multidisciplinary approach, based on the operational user requirements and actively involving the end-user throughout the development process. In the development process, emphasis should be on problem solving rather than marketing the tools available to solve these very problems.

24. Access to and exchange of remote sensing data and related information technology should be facilitated through international support and by national priority setting, through appropriate policies, possibly using technical cooperation among developing countries (TCDC) concepts.

25. An internationally coordinated information network and repository should be developed, using Internet technology. It should contain information on ongoing and planned projects, lists of experts, demonstrations of successful applications in different theme areas, contact addresses of value-adding companies, activities of organizations and specialized agencies of the United Nations and the Consultative Group on International Agricultural Research (CGIAR) centres, funding possibilities for education and training as well as relevant public domain software (e.g. GIS packages).

26. By integrating projects into a programme, their sustainability, maintainability and funding will be strengthened.

27. In addition to the technical conclusions, it was recommended that the United Nations/IAF series of workshops should be used as an important instrument in

implementing the recommendations of UNISPACE III. The planning of workshops should be a more continuous process, with the active involvement of all key players, and be undertaken on a more solid funding base.

A. Recommended actions

28. The United Nations Office for Outer Space Affairs, in the context of the follow up to UNISPACE III and in consultation with the relevant bodies and specialized agencies of the United Nations system and the CGIAR centres, should promote the further development of a comprehensive, Internet-based information repository with an open network structure to include the type of information described in paragraph 25 above. The information repository should take into account existing information systems such as the Locator Information System (CILS) of the Committee on Earth Observation Satellites (CEOS). Throughout the promotion process, the information repository should be brought to the attention of developing countries in order that they might benefit from its use and contribute to its enrichment by including their national experiences. A report on the follow-up to the present recommendation should be presented to the UnitedNations/IAF Workshop to be held in Brazil in 2000.

29. Emphasis on education and training and the raising of awareness should be placed in future workshops and other activities organized by the United Nations.

B. Recommended actions for future United Nations/IAF Workshops

30. Workshops should be planned and executed as a project, including, among other things, the establishment of timelines, key decision points and events, assignment of responsibilities and funding commitments. It was particularly important to carry out focused and coordinated actions in order to establish a more solid funding base.

31. The early and continuous involvement of organizations in the host country should be ensured.

32. The formulation and development of programmes of workshops should be coordinated among agencies involved.

III. Presentations and discussions

33. The Workshop was opened with welcoming statements by the representative of the United Nations, the President of IAF and representatives from ITC, ESA, CNES, the Committee for the Liaison of Industrialized Organizations with Developing Nations (CLIODN) and the Government of the Netherlands.

34. In the first keynote address on "Space technology applications enabling sustainable development— applications for disaster warning, food security and resources management", a representative of the Institute of Remote Sensing Applications of the Chinese Academy of Sciences introduced the theme of the Workshop. The representative noted that sustainable development was possible only under the condition that sufficient information was available for decision-making. Space systems could form a central and integral part of an economically viable and realistic information system needed for sustainable development.

35. In the second keynote address, a representative of EUMETSAT, on behalf of CEOS described the status of the Integrated Global Observing Strategy (IGOS).

A. Need for space-acquired information in support of sustainable development

36. The representative of the United Nations Office for Outer Space Affairs introduced the United Nations Programme on Space Applications and a summary of the UNISPACE III recommendations related to the management of natural resources. The recommendations resulting from the UNISPACE III conference could enhance international cooperation in improving and coordinating the application of space-acquired information, provided that the commitments made were supported by sufficient resources.

37. The representative of IWMI stressed the important role of Earth observation satellites, indicating that the management of natural resources required specific measurements of relevant parameters in order to give a clear picture of the overall situation on the ground. Remote sensing was a powerful tool for that purpose. In order to strengthen the implementation of the use of remote sensing in development projects, however, it was necessary to convince key decision makers, link space applications with those development projects, take into

account capacity- building components and demonstrate that reliable accuracy was achievable.

38. A concept for forest management, the Forest Assessment and Monitoring Environment (FAME) initiative for the realization of a global end-to-end service to allow the monitoring of forests at national and subnational levels, was presented by a representative of NLR. The concept took into account the lessons learned from previous pre-operational remote sensing projects.

B. Financing for implementation of the operational use of space technologies

39. One of the main obstacles in using space technology applications was the change from proving a concept to using an application, which often required a different perspective with regard to the user group, the project size and the funding resources. While space agencies like ESA could assist with pre-operational and demonstration projects, they had no mandate to support and sustain the operational use of space applications. Funds for such initiatives could be obtained as loans from various international organizations, but the funds would eventually have to be returned.

40. One such possible organization was the African Development Bank, which was established in 1963 to promote economic development in Africa. The Bank had 77 members, 23 of them outside Africa, and administered a capital of $31.5 billion. The main task was to support projects which aim to reduce poverty. Priority was therefore given to applications in agriculture, the development of human resources and the private sector.

41. The Bank did not directly fund research projects, but would fund remote sensing applications if they were part of other projects meeting the Bank's funding criteria. Pilot projects had been funded in the past. The bank published a monthly list of projects eligible for funding. In theory, remote sensing consultants could utilize this information to offer their services to those projects. One application of remote sensing would be to support environmental impact analyses of a project. Such an impact analysis was a mandatory part of the Bank's evaluation process, and the Bank therefore had a whole branch devoted to it. It had not, however, developed any in-house remote sensing capabilities.

42. The presentation of the World Bank focused on the spending priorities of the world. The World Bank recognized the benefits of space applications to society and had funded several projects in the past. Examples included a number of case studies in India, for example, the assessment of soils for increasing agricultural productivity and various disaster management support services. Within the World Bank itself, remote sensing and GIS technologies were being used, mainly for environmental assessment studies.

C. Health, communication and navigation and location systems

43. Presentations focused on new trends and applications of space technology in the health, communication and navigation and location systems. A NASA representative discussed how remote sensing technology could be used for health applications. As with other remote sensing applications, the challenge was to transfer the tools into the hands of the users and to sustain the activities. Once it had been proved that an application could provide solutions, the user community needed to step forward to take over the day-to-day operations. It was therefore necessary to include the user community from the start of the project.

44. A representative of Station 12®, a commercial telecommunications applications provider, gave an overview of the current state of the art of personal mobile satellite communications systems. Driven by the competition in the field, prices for such applications had decreased considerably over the last few years, making them affordable for developing countries.

D. Institutional capacity building and human resources development

45. The session featured a presentation analysing the problems encountered in institutional capacity building for the use of remote sensing in India; a report on the results of the first national conference on space applications in Sri Lanka, which was aimed at preparing a national plan for applications of space technology; and a presentation on the challenges and opportunities for developing countries in using space technology for sustainable development in the post-UNISPACE III era.

E. Working group discussions on water resources management

46. Presentations at the session on water resources management were split into two parts, one covering global water issues, challenges and the role of remote sensing, and the other covering national and regional approaches to using remote sensing for water resource applications.

47. A representative of NRSA reported on the achievements in implementing the use of remote sensing in water resources management in India and on actions that were being taken to further integrate the applications with existing institutional frameworks. How remote sensing technology could be transferred from water resources research to management was also discussed by an ITC representative. Other presentations focused on operational flood monitoring in Bangladesh using low-cost radar receiving facilities; the role of remote sensing in solving hydrological problems in China; the use of Landsat and NOAA imagery to create an evapotranspiration map for semi-arid areas in Botswana; and the description of a user interface for data and image management for the use of space techniques as a tool in the integrated management of river basin water resources.

F. Working group discussions on sustainable forest management

48. Presentations and discussions in the working group on sustainable forest management focused, on the one hand, on global forestry issues and, on the other, on national and regional approaches to using remote sensing for forestry management. Applications of forestry management in Nepal, the Amazon region and Indonesia were discussed, as well as capacity-building programmes, for example, the FAME initiative of FAO and the Government of the Netherlands. The session highlighted the need to use remote sensing as a tool for forest management purposes.

G. The way forward: recommendations and follow-up

49. The recommendations of the Workshop are presented in chapter II, above. They were based on the contributions made by the participants and the input provided by the review panel. Follow-up activities would be carried out throughout the year 2000, possibly though inter-agency coordination and with the participation of interested space-related institutions.

Notes

[1] See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-21 August 1982* (A/CONF.101/10 and Corr.1 and 2), part one, para. 430.

[2] *Official Records of the General Assembly, Fifty-third Session, Supplement No. 20* (A/53/20), para. 51.

[3] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (A/CONF.184/6), chap.I, resolution 1.

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Disposal of satellites in geosynchronous orbit

Report by the Secretariat

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I. Introduction

1. At its forty-second session, the Committee on the Peaceful Uses of Outer Space agreed[1] that the Scientific and Technical Subcommittee, at its thirty-seventh session, should review international application of the International Telecommunications Union (ITU) standards and Inter-Agency Space Debris Coordination Committee (IADC) recommendations concerning the disposal of satellites in geosynchronous orbit at the end of their useful life. It also recommended that, to facilitate the review by the Subcommittee, the Secretariat should compile relevant data on space objects in geosynchronous orbit.

2. The present report was prepared by the Secretariat in response to the request by the Committee. It incorporates information received from the Canadian Space Agency (CSA), the Centre National d'Etudes Spatiales (CNES) of France, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and Intelsat. The Secretariat wishes to express its appreciation to the Astronomical Institute of the Czech Academy of Sciences, Czech Republic, the European Space Operations Centre (ESOC) of the European Space Agency (ESA) in Darmstadt, Germany, and Johnson Space Center of the National Aeronautics and Space Administration (NASA) in Houston, United States of America for their valuable assistance in the preparation of the present report.

II. Standards and recommendations on geosynchronous satellite disposal

3. During the 1980s, ITU began addressing the issue of end-of-mission disposal and supersynchronous graveyard orbits. In 1986, the ITU International Consultative Committee for Radio (CCIR) assigned question 34.4 to Study Group 4 to examine six questions associated with the potential for physical interference in geosynchronous Earth orbit (GEO) and with the removal of spacecraft from GEO. After many years of fact-finding and scientific discussion, ITU concluded that some measures to limit the growth of the geosynchronous satellite population were prudent.

4. Specifically, it was recommended that:[2]

(a) As little debris as possible should be released into the geostationary satellite orbit (GSO) during the placement of a satellite in orbit;

(b) Every reasonable effort should be made to shorten the lifetime of debris in the transfer orbit;

(c) A geostationary satellite at the end of its life should be transferred, before complete exhaustion of its propellant, to a supersynchronous graveyard orbit that does not intersect the GSO;

(d) The transfer to the graveyard orbit should be carried out with particular caution in order to avoid radio frequency interference with active satellites;

(e) The following footnote should be considered part of this recommendation: "Further studies are required to define what constitutes an effective graveyard orbit".

5. By the time the ITU recommendations were published, more than 90 spacecraft had already been manoeuvreed out of GEO into a wide variety of disposal orbits, following the precedent set by Intelsat in 1977. In the early 1980s, the written policy of Intelsat was to desynchronize unusable spacecraft 40 to 50 km upward, but a decade later it had raised the minimum altitude to 150 km (see chapter III).

6. Although ITU did not explicitly recommend a specific super-synchronous disposal (graveyard) orbit, its definition of GSO "as a mean radius of 42,164 ± 300 km and extending to 15 degrees north and south latitude" dictated a minimum perigee of the disposal orbit 300 km above GSO.[3]

7. At the twelfth meeting of IADC in Houston in March 1995, action item 12.6 was assigned to Working Group 4 (Mitigation) to review the 1993 ITU recommendation on GSO spacecraft disposal orbits. After extensive scientific debate, IADC, representing the world's leading space agencies, reached a consensus on a new formulation for determining the minimum altitude of disposal orbits, one based upon clearly identified factors.[4]

8. The IADC recommendation recognized that the vast majority (over 97 per cent) of operational GSO spacecraft maintain perigees and apogees within 75 km of GSO. Furthermore, regions extending 125 km on either side of this operational zone were needed as spacecraft translation corridors to permit initial station acquisition and subsequent relocations. To ensure that the upper operational zone and the translation corridor would not intersect with disposal orbits, buffer zones of 35 km and 10-200 km were established to account for orbital perturbations by gravitational forces and solar radiation forces, respectively. The simplified formula is given as

$$\Delta H = 235 + 1000 \times C_R \times A/m,$$

where ΔH is the minimum altitude of the disposal orbit perigee above GSO in kilometres, C_R is the solar radiation pressure coefficient (usually with a value between 1 and 2), A is the average cross-sectional area and m is the mass of the satellite. This means that for a spacecraft with an A/m of 0.01 m^2/kg, the minimum perigee of disposal orbit should be 245 km above GSO altitude and for spacecraft with 0.10 m^2/kg and $C_R = 2$, it should be 435 km.

III. Examples of the GSO disposal policy

9. In order to prepare the present report, the Secretariat requested satellite operators to provide information on their general policy regarding the disposal of satellites in GSO and on the status of spacecraft they operated near GSO. The substantive responses are summarized below.

A. Intelsat

10. Intelsat has self-imposed policies and procedures to properly decommission "expended" satellites and to prevent the generation of space debris. The existing policies and procedures on general satellite designs, launch operations, satellite operations, satellite anomalies and satellite decommissioning are:

1. General satellite design

Intelsat satellite procurement documentation specifies designs that minimize outgassing and space debris generation during transfer orbit deployments and in-orbit operations.

Intelsat uses satellite designs that are self-contained and generate no orbital debris.

Satellites are equipped, when possible, with measurement devices to assist in determining end-of-propellant conditions.

2. Launch operations

A dialogue is maintained with United States Space Command. Intelsat furnishes launch information and orbital parameters upon request.

3. Satellite operations

Detailed satellite propellant budgets are maintained, including a record of all manoeuvres. Mathematical models are employed to calculate propellant usage and predict remaining reserves. These models are continually updated with flight data.

A propellant uncertainty margin is used to hold back on-board propellant reserves and guarantee that satellites are not stranded in-orbit.

Multiple ground stations are used to track and command satellites in order to provide full redundancy during in-orbit operations or emergency conditions.

Satellite telemetry is continually monitored and compared against preset limits. Alarms are used to alert ground teams of any anomalies.

Battery capacity and power subsystem performance is continually monitored on all satellites. Emergency procedures are in place to "shed load" when low battery or power conditions are noted.

Contingency plans and procedures are available for emergency response: on-call engineering staff are available for immediate 24-hour consultation.

Intelsat abides by standard protocols during orbital relocations and coordinates all activities with the other satellite owners/operators.

4. Satellite anomalies

Contingency plans call for immediate orbit raising and decommissioning of any satellite that is likely to be stranded in the geosynchronous orbital arc. The Director of Satellite Engineering Support and Processes has the authority to make this decision; no other approvals or authorizations are required.

5. Satellite decommissioning

At decommissioning, all satellites are placed into a safe, passive mode. This includes depressurization and venting of propellant systems as part of orbit raising, discharge of batteries and turning off of all radio frequency units to preclude interference with any other satellite owner/operators.

For older satellites, sufficient propellant is held back to raise the orbit to a minimum altitude of 150 km above geosynchronous at decommissioning. This

manoeuvre is normally done in multiple parts over several days to guarantee a good parking orbit. For newer satellites, starting with Intelsat VI, a minimum decommissioning altitude of 300 km has been adopted. Because of conservative propellant budgeting, Intelsat normally exceeds the targeted decommissioning altitude.

B. Canadian Space Agency

11. Canada does not have an official GSO disposal policy. It is however considered to be good business judgement to protect present and future spacecraft and respective orbital positions by moving retired objects out of the way. The Canadian space operator Telesat nominally aims for a disposal orbit at 300 kilometres, but there are technical factors that will affect the amount of displacement achieved.

12. The resulting displacement value for retired satellites is generally positive, but in several cases it is less than 300 kilometres (see tables in the annex). The Canadian Government satellite CTS/Hermes (1976-004A) was not controlled by Telesat. It was initially stationed at 116 degrees west longitude, but was later moved to 142 degrees to conduct some experiments with Australia. The control of the satellite was lost on 24 November 1979 while at this position. As a result, it was not possible to move it into proper disposal orbit.

C. Centre National d'Etudes Spatiales

13. The French space agency CNES is focusing its attention on enhancing the understanding of the current debris environment and on the establishment of a French standard to provide space project managers with guidelines on how to reduce risk levels. For satellites in geosynchronous orbit, CNES has applied, since 1983, de-orbiting measures for satellites under its control, except for satellites that failed during their operational mission (e.g. Telecom 1B, 1985-035B). CNES has already adopted the recommendation of IADC concerning the minimum altitude of the disposal orbit for geostationary satellites. A list of disposed satellites is included in tables in the annex.

D. European Space Agency

14. The European Space Agency (ESA) had studied as early as 1979 the collision risk in the geostationary ring and has proposed the use of a disposal orbit in order to protect operational geostationary satellites. The first ESA satellite to be removed from the geostationary orbit was ESA-GEOS 2 (1978-071A) in January 1984. In 1989, ESA objectives in the field of space debris were formulated and approved by its Council. They included a policy to reorbit its geostationary satellites at the end of their operational life to a disposal orbit located at least 300 km above the geostationary orbit. The ESA paper entitled "Space debris mitigation handbook" contains the IADC recommendation on the reorbiting of geostationary satellites at the end of their operational life. A list of disposed satellites is included in tables in the annex. As a consequence of a spacecraft anomaly, the satellite Olympus 1 (1989-053A) could only be transferred to a disposal orbit below the geostationary orbit.

E. EUMETSAT

15. As a general practice, EUMETSAT removes non-functioning spacecraft from the geostationary arc wherever possible. EUMETSAT activity in this area is not governed by a formal policy, but it generally aims to follow the best practice observed by other satellite operators. A list of disposed satellites is included in tables in the annex.

IV. Situation near the geostationary orbit

16. The situation in the region of geostationary orbit, as of about 1 July 1999, is presented in figures and tables in the annex. The number of spacecraft, upper stages and end-of-life (EOL) manoeuvres is given in figures 1 and 2 and in table 1, which were provided by the NASA Johnson Space Center. From 1963 to 1999, as many as 573 spacecraft and almost 200 upper stages were launched near GSO. By mid-1999, the number of operational GSO spacecraft was estimated at 270, and more than 160 spacecraft had been removed from GSO. Dates of EOL manoeuvres, when available, are given in tables 2 to 5.

17. Tables 2 to 5 are based on the document "Classification of geostationary objects, issue 1", issued by ESOC in August 1999; information was checked and amended using information provided by other sources (see paragraph 2). The completeness of lists of objects near GSO is limited by several factors. In the first place, orbital elements of some objects are not publicly available. In the second place, objects smaller than about 1 metre in size cannot be routinely detected and catalogued. Orbital elements appear in the NASA Two-Line Elements (TLE) and are processed by ESOC and Information System for the Characterization of Objects in Space (DISCOS). The ESOC document mentioned above contains a detailed analysis of available orbital elements for objects in and near the geostationary orbit.

18. The tables in the present report include only spacecraft, not rocket stages and other debris. Spacecraft are divided into different categories according to their minimal distance from the geosynchronous orbit. The objects listed in table 2 fully conform to the ITU standard of minimal 300 km disposal distance from GSO. The objects listed in tables 3 and 4 do not cross the GSO altitude, but they are not at a safe distance from it, and orbital perturbations might cause changes in their orbits which would change their category in the future. Some objects are disposed below the GSO altitude (table 4). Finally, objects listed in table 5 are currently crossing the geostationary orbit and are potentially dangerous to active satellites there.

19. In the column labelled "status" in tables 2 to 5, the general category and corresponding number from the ESOC document "Classification of geostationary objects" are given for easy identification. Active satellites in the C category, which are under the regime of full longitude and inclination control (C1) or only longitude control (C2) have not been taken into account. The fact that a satellite has terminated its useful life is, in principle, determined by the decision of its owner or operator. In the absence of published statements, an indication of the inactivity of satellites is the discontinuation of station-keeping manoeuvres and the drift of satellites from their original nominal positions. It may, however, happen that a satellite is repositioned from one nominal position into another one by putting it into a drift orbit.

20. Most of the objects under consideration are in drift orbits, category D, and are apparently not under station keeping. The mean deviations of their perigees and apogees from the geostationary radius of 42,164 km have been listed as well as their inclinations. The remaining objects are listed under the L category, which means that they are librating (oscillating) around the so-called eastern stable point at 75 degrees east longitude (L1 category), western stable point at 107 degrees west longitude (category L2) or even around both points (L3 category). The libration orbits are rather complicated. They are very close to the nominal GSO altitude, and some cross the GSO twice daily while others cross it only at some phases of their libration period. Therefore their perigee and apogee altitudes have not been listed. Objects of indeterminate status, category Ind, have not been included. Some of the objects in that category might be active; for others, additional information would be needed, possibly provided by their owners or operators, to determine their status.

V. Conclusions

21. The ITU standards and IADC recommendations have been developed quite recently and are not mandatory. It is therefore very difficult to evaluate their international application. Most satellite operators are aware of the seriousness of the situation near GSO and have acknowledged the wisdom of taking some mitigation measures. Because of technical and managerial problems, however, even self-imposed guidelines are not being followed in many cases. For geostationary orbit-protection measures to become effective, a broad international consensus should be reached on the guidelines, and systematic monitoring of their implementation seems to be necessary.

Notes

[1] Official Records of the General Assembly, Fifty-fourth Session, Supplement No. 20 (A/54/20), para. 44.

[2] "Environmental protection of the geostationary-satellite orbit." In 1993-ITU-R recommendations, ITU-R S series, ITU-R S.1003 (Geneva, Fixed Satellite Service, 1993).

[3] Ibid.

[4] *Fifteenth Inter-Agency Space Debris Coordination Committee Meeting Proceedings, 9-12 December 1997* (Houston, NASA Johnson Space Center, 1998).

Annex

Statistical data

Figure 1
Spacecraft and upper stages placed near the geostationary satellite orbit

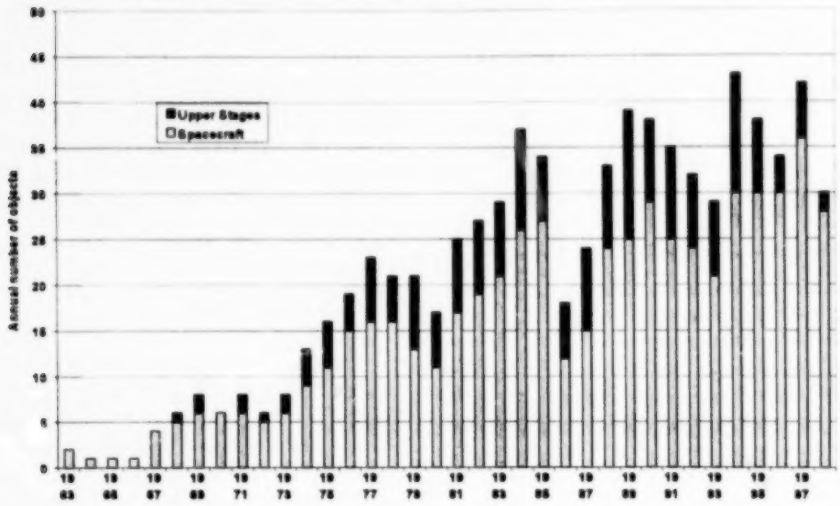

Figure 2
New spacecraft and end-of-life manoeuvres

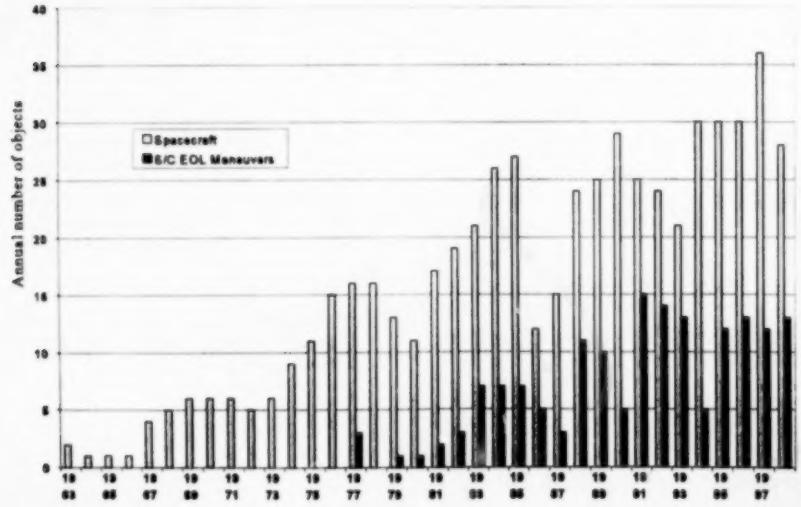

Table 1
Statistics of geostationary satellite orbit operations

Year	*Spacecraft*	*S/C EOL Manoeuvres*	*Upper Stages*
1963	2	0	0
1964	1	0	0
1965	1	0	0
1966	1	0	0
1967	4	0	0
1968	5	0	1
1969	6	0	2
1970	6	0	0
1971	6	0	2
1972	5	0	1
1973	6	0	2
1974	9	0	4
1975	11	0	5
1976	15	0	4
1977	16	3	7
1978	16	0	5
1979	13	1	8
1980	11	1	6
1981	17	2	8
1982	19	3	8
1983	21	7	8
1984	26	7	11
1985	27	7	7
1986	12	5	6
1987	15	3	9
1988	24	11	9
1989	25	10	14
1990	29	5	9
1991	25	15	10
1992	24	14	8
1993	21	13	8
1994	30	5	13
1995	30	12	8
1996	30	13	4
1997	36	12	6
1998	28	13	2
Total	**573**	**162**	**195**

Table 2

Spacecraft with perigees more than 300 km above the geostationary satellite orbit

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man*
D.-	1969-045A	Intelsat 3 F-4 (34)	3699 km	3965 km	6.1	1977
D.401	1970-003A	Intelsat 3 F-6 (36)	398 km	755 km	5.18	1977
D.111	1971-006A	Intelsat 4 F-2 (42)	344 km	470 km	15.29	1983
D.110	1972-090A	Telesat 1 (Anik 1)	352 km	468 km	13.89	1982
D.39	1973-100A	DSCS 3	629 km	872 km	16.04	1990
D.31	1973-100B	DSCS 4	491 km	1089 km	15.52	1993
D.94	1974-033A	SMS 1	411 km	533 km	17.33	1981
D.15	1976-053A	Marisat 2	720 km	1824 km	14.36	1996
D.9	1977-005A	NATO 3B	1272 km	1656 km	13.22	1993
D.22	1977-034A	DSCS 7	957 km	1123 km	15.20	1981
D.11	1977-034B	DSCS 8	1266 km	1566 km	14.87	1990
D.117	1977-118A	Sakura 1 (CS-1)	366 km	405 km	13.37	1985
D.87	1978-106A	NATO 3C	482 km	535 km	10.78	1992
D.2	1978-113A	DSCS 11	1741 km	1950 km	14.94	1993
D.84	1978-113B	DSCS 12	502 km	541 km	12.78	1992
D.89	1979-038A	Fleetsatcom 2	421 km	564 km	12.81	1992
D.13	1979-098A	DSCS 13	1327 km	1400 km	12.59	1993
D.82	1979-098B	DSCS 14	525 km	570 km	12.43	1995
D.98	1980-049A	Gorizont 4	443 km	492 km	13.73	1988
D.114	1980-098A	Intelsat 5 F-2 (502)	320 km	467 km	8.19	1998
D.112	1981-050A	Intelsat 5 F-1 (501)	383 km	421 km	8.70	1997
D.103	1981-057A	Meteosat 2	318 km	562 km	9.84	1991
D.93	1981-073A	Fleetsatcom 5	435 km	513 km	12.97	1986
D.6	1981-122A	Marecs 1	1012 km	2056 km	9.59	1996
D.88	1982-020A	Gorizont 5	358 km	634 km	13.03	1989
D.7	1982-106A	DSCS 15	1509 km	1528 km	9.99	1997
D.47	1982-113A	Raduga 11	554 km	916 km	11.84	1989
D.5	1983-016A	Ekran 10	1375 km	1700 km	13.35	1985
D.113	1983-058A	ECS 1	371 km	425 km	7.57	1996
D.81	1983-066A	Gorizont 7	494 km	603 km	11.30	1989
D.108	1983-081A	Sakura 2B (CS-2B)	390 km	439 km	8.74	1990
D.75	1983-088A	Raduga 13	527 km	671 km	11.36	1987
D.80	1983-118A	Gorizont 8	468 km	675 km	10.97	1988
D.28	1984-023A	Intelsat 5 F-8 (508)	858 km	772 km	6.38	1994
D.18	1984-028A	Ekran 12	1182 km	1266 km	12.40	1988
D.108	1984-081A	ECS 2	390 km	448 km	6.87	1993
D.83	1984-081B	Telecom 1A	379 km	686 km	6.79	1992
D.17	1984-090A	Ekran 13	1176 km	1295 km	11.65	1989
D.29	1984-093C	Leasat 2	681 km	936 km	11.82	1996
D.90	1984-113C	Leasat 1	354 km	629 km	6.23	1992
D.3	1985-024A	Ekran 14	1532 km	1685 km	11.38	1988
D.25	1985-028C	Leasat 3	618 km	1290 km	13.15	1996
D.50	1985-076D	Leasat 4	677 km	739 km	8.41	1988
D.120	1985-087A	Intelsat 5A F-12 (512)	305 km	350 km	4.12	1998
D.20	1986-038A	Ekran 15	1011 km	1145 km	10.27	1988

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man.*
D.86	1986-082A	Raduga 19	474 km	558 km	8.74	1993
D.23	1986-090A	Gorizont 13	954 km	1096 km	8.78	1991
D.16	1987-028A	Raduga 20	1136 km	1370 km	9.23	1991
D.40	1987-040A	Gorizont 14	635 km	864 km	10.27	1992
D.19	1987-073A	Ekran 16	1082 km	1111 km	9.10	1989
D.14	1987-109A	Ekran 17	1100 km	1455 km	7.71	1993
D.74	1988-012A	Sakura 3A	570 km	650 km	2.52	1996
D.54	1988-028A	Gorizont 15	564 km	836 km	7.72	1992
D.8	1988-036A	Ekran 18	1447 km	1554 km	8.61	1990
D.24	1988-051A	Meteosat 3	933 km	985 km	5.49	1995
D.21	1988-108A	Ekran 19	936 km	1154 km	6.97	1997
D.26	1989-020B	Meteosat 4	911 km	834 km	4.30	1995
D.102	1989-048A	Raduga 1-01	371 km	518 km	6.39	1996
D.107	1990-077A	Yuri 3A (BS-3A)	375 km	456 km	1.07	1998
D.116	1991-046A	Gorizont 23	354 km	420 km	4.77	1992
D.105	1991-060A	Yuri 3B (BS-3B)	406 km	436 km	1.85	1999
D.85	1991-074A	Gorizont 24	447 km	595 km	4.47	1998

Table 3

Spacecraft with perigees between 0 and 300 km above the geostationary satellite orbit

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man.*
D.37	1968-116A	Intelsat 3 F-2 (32)	195 km	1326 km	15.45	1977
D.152	1969-069A	ATS 5	195 km	247 km	15.19	1984
D.161	1971-116A	Intelsat 4 F-3 (43)	130 km	237 km	13.74	1983
D.180	1972-003A	Intelsat 4 F-4 (44)	106 km	143 km	13.23	1983
D.220	1972-041A	Intelsat 4 F-5 (45)	26 km	65 km	13.91	1983
D.175	1973-023A	Telesat 2 (Anik 2)	66 km	201 km	13.07	1982
D.124	1973-058A	Intelsat 4 F-7 (47)	296 km	343 km	13.28	1983
D.190	1974-022A	Westar 1	72 km	139 km	12.76	1983
D.184	1974-075A	Westar 2	97 km	139 km	12.56	1986
D.173	1974-093A	Intelsat 4 F-8 (48)	116 km	158 km	11.89	1985
D.198	1974-101A	Symphonie	68 km	107 km	14.74	1983
D.153	1975-011A	SMS 2	166 km	265 km	14.52	1982
D.213	1975-038A	Telesat 3 (Anik 3)	39 km	87 km	12.03	1984
D.136	1975-042A	Intelsat 4 F-1 (41)	235 km	338 km	11.91	1987
D.200	1975-077A	Symphonie 2	57 km	113 km	14.84	1985
D.194	1975-091A	Intelsat 4A F-1 (411)	74 km	119 km	11.87	1986
D.160	1975-117A	RCA Satcom 1	80 km	303 km	11.99	1984
D.164	1976-010A	Intelsat 4A F-2 (412)	139 km	191 km	12.04	1985
D.129	1976-017A	Marisat 1	265 km	338 km	13.50	1997
D.96	1976-029A	Satcom 2	229 km	708 km	11.77	1985
D.183	1976-035A	NATO 3A	13 km	229 km	12.97	1992
D.179	1976-042A	Comstar 1A	104 km	150 km	11.86	1987
D.217	1976-066A	Palapa 1	38 km	63 km	11.65	1988
D.202	1976-073A	Comstar 1B	66 km	100 km	11.72	1994
D.205	1977-014A	KIKU 2	54 km	95 km	14.26	1991
D.209	1977-018A	Palapa 2	42 km	88 km	10.85	1991
D.148	1977-041A	Intelsat 4A F-4 (413)	179 km	290 km	11.00	1989
D.135	1977-065A	Himawari 1	230 km	349 km	13.74	1989
D.192	1978-002A	Intelsat 4A F-3 (414)	84 km	121 km	10.52	1988
D.123	1978-044A	OTS 2	283 km	358 km	12.30	1991
D.128	1978-068A	Comstar 1C	214 km	395 km	10.41	1986
D.140	1978-071A	ESA-GEOS 2	220 km	286 km	14.27	1984
D.177	1978-116A	Telesat 4 (Anik)	106 km	151 km	9.95	1986
D.197	1979-072A	Westar 3	69 km	114 km	8.91	1990
D.133	1980-074A	GOES 4	140 km	450 km	12.40	1988
D.178	1980-091A	SBS 1	103 km	150 km	9.60	1991
D.156	1981-076A	Himawari 2	152 km	254 km	12.07	1989
D.228	1981-096A	SBS 2	23 km	55 km	8.73	1996
D.221	1981-114A	Satcom 3R	22 km	66 km	6.50	1991
D.151	1981-119A	Intelsat 5 F-3 (503)	140 km	313 km	7.89	1998
D.159	1982-004A	Satcom 4	172 km	214 km	5.87	1991
D.171	1982-014A	Westar 4	121 km	162 km	5.94	1991
D.132	1982-017A	Intelsat 5 F-4 (504)	177 km	414 km	7.90	1995
D.130	1982-058A	Westar 5	228 km	370 km	5.65	1992

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man.*
D.222	1982-082A	Telesat 5 (Anik D1)	13 km	74 km	6.26	1991
D.195	1982-110B	SBS 3	61 km	129 km	6.01	1995
D.191	1982-110C	Telesat 6 (Anik C3)	83 km	123 km	6.07	1997
D.144	1983-006A	Sakura 2A	198 km	292 km	9.29	1991
D.185	1983-030A	Satcom 1R	79 km	152 km	5.06	1992
D.125	1983-047A	Intelsat 5 F-6 (506)	288 km	339 km	6.53	1998
D.121	1983-059B	Telesat 7 (Anik C2)	154 km	498 km	5.94	1998
D.226	1983-065A	Galaxy 1	23 km	57 km	4.20	1994
D.154	1983-077A	Telstar 3A	112 km	310 km	4.37	1996
D.145	1983-094A	Satcom 2R	178 km	307 km	3.48	1995
D.165	1983-105A	Intelsat 5 F-7 (507)	129 km	197 km	6.86	1996
D.118	1984-005A	Yuri 2A	294 km	396 km	8.60	1989
D.181	1984-080A	Himawari 3	95 km	153 km	8.45	1995
D.172	1984-093D	Telstar 3C	121 km	157 km	3.46	1997
D.182	1984-101A	Galaxy 3	88 km	156 km	3.50	1995
D.115	1984-113B	Telesat 8 (Anik D2)	265 km	509 km	4.74	1995
D.169	1984-114A	Spacenet 2	96 km	195 km	1.85	1998
D.149	1985-048B	Morelos 1	214 km	241 km	4.16	1994
D.188	1985-048D	Telstar 3D	105 km	118 km	3.20	1999
D.170	1985-076B	Aussat-1	122 km	166 km	5.02	1993
D.157	1986-003B	Satcom K1	186 km	220 km	2.15	1997
D.109	1986-007A	Raduga 18	127 km	702 km	9.43	1991
D.137	1986-016A	Yuri 2B	205 km	351 km	6.78	1992
D.174	1986-026A	Gstar 2	115 km	155 km	3.34	1997
D.193	1987-029A	Palapa 5	76 km	127 km	2.73	1998
D.138	1987-070A	KIKU 5	216 km	315 km	6.05	1997
D.122	1987-095A	TV-Sat 1	265 km	376 km	8.07	1989
D.63	1988-018B	Telecom 1C	251 km	1081 km	3.21	1996
D.201	1988-071A	Gorizont 16	25 km	143 km	7.06	1991
D.131	1988-086A	Sakura 3B	270 km	323 km	1.63	1997
D.127	1988-098A	TDF 1	291 km	320 km	2.47	1996
D.163	1988-109A	Skynet 4B	153 km	178 km	5.53	1998
D.119	1989-004A	Gorizont 17	261 km	423 km	6.68	1997
D.155	1989-020A	JCSAT 1	188 km	229 km	1.67	1998
D.126	1989-027A	TELE-X	287 km	330 km	1.98	1998
D.167	1989-041A	Superbird A	125 km	171 km	6.57	1991
D.142	1989-052A	Gorizont 18	100 km	393 km	6.26	1996
D.92	1990-063A	TDF 2	267 km	681 km	0.66	1999
D.-	1993-015A	UFO 1	253 km	322 km	22.90	1993
D.158	1993-039A	Galaxy 4	121 km	1274 km	0.93	1998

Table 4

Spacecraft below the geostationary satellite orbit with apogees between 0 and -400 km

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man.*
D.290	1968-081A	OV 2-5	-709 km	- 3 km	13.12	
D.294	1974-039A	ATS 6	-599 km	-346 km	14.74	1980
D.240	1985-015A	Arabsat 1A	- 73 km	-10 km	6.53	1992
D.258	1988-034A	Kosmos 1940	-207 km	-14 km	7.45	1988
D.256	1989-041B	DFS 1 Kopernikus 1	-168 km	-49 km	2.82	1995
D.283	1989-053A	Olympus 1	-381 km	-228 km	5.47	1993

Table 5

Spacecraft crossing the geostationary satellite orbit

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man.*
D.402	1964-047A	Syncom 3	- 43 km	72 km	8.55	
L2.21	1965-028A	Intelsat 1 F-1 Early Bird			13.41	
D.236	1966-110A	ATS 1	-59 km	25 km	13.91	
D.235	1967-001A	Intelsat 2 F-2 (22)	-46 km	98 km	14.42	
L3.5	1967-026A	Intelsat 2 F-3 (23)			13.79	
L2.24	1967-094A	Intelsat 2 F-4 (24)			14.25	
L41.3	1968-081C	ERS-21 (OV 5-4)			13.58	
L2.19	1968-081D	LES 6			13.57	
L1.3	1968-081C	OV 5-4			13.58	
L1.1	1969-011A	Intelsat 3 F-3 (33)			6.09	1979
D.403	1969-013A	Tactical Comsat 1	- 38 km	15 km	14.52	
L2.6	1969-101A	Skynet 1A			14.65	
L2.9	1970-021A	NATO 1			14.38	
L42.1	1970-032A	Intelsat 3 F-7 (37)			0.85	
D.295	1970-055A	Intelsat 3 F-8 (38)	-1960 km	863 km	13.48	Failed to GEO
L2.8	1971-009A	NATO 2			15.18	
L2.10	1971-095A	DSCS 1			15.15	
L3.1	1971-095B	DSCS 2			15.05	1993
D.259	1974-017A	Kosmos 637	- 314 km	31 km	14.77	
L1.42	1974-060A	Molniya S1			15.17	
L1.68	1974-094A	Skynet 2B			14.25	
L1.47	1975-097A	Kosmos 775			15.15	
L2.15	1975-100A	GOES 1			14.60	
L1.13	1975-123A	Raduga 1			15.04	
L2.18	1976-004A	CTS 1 (Hermes)			14.89	Failed 1979
L2.11	1976-023A	LES 8			13.00	
L2.2	1976-023B	LES 9			12.99	
L1.15	1976-092A	Raduga 2			15.01	
L1.26	1976-107A	Ekran 1			14.98	
L1.48	1977-071A	Raduga 3			14.84	
L1.54	1977-080A	Sirio 1			12.54	
L1.31	1977-092A	Ekran 2			14.79	
L1.65	1977-108A	Meteosat 1			14.32	
L1.69	1978-035A	Intelsat 4A F-6 (416)			10.51	
L1.43	1978-039A	Yuri 1 (BSE 1)			14.14	
L2.7	1978-062A	GOES 3			12.65	1995
L1.46	1978-073A	Raduga 4			14.55	
D.-	1978-118A	Gorizont 1	-13938 km	13946 km	25.10	Failed to GEO
L1.33	1979-015A	Ekran 3			14.33	
L1.12	1979-035A	Raduga 5			14.29	
L1.17	1979-062A	Gorizont 2			13.99	
L1.25	1979-087A	Ekran 4			14.08	
L1.44	1979-105A	Gorizont 3			13.79	
L2.33	1980-004A	Fleetsatcom 3			11.66	
L1.41	1980-016A	Raduga 6			13.90	

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man*
D.405	1980-018A	Ayame 2	-3002 km	1053 km	1.39	Failed to GEO
L41.2	1980-060A	Ekran 5			11.33	
L2.27	1980-081A	Raduga 7			13.57	
L1.30	1980-104A	Ekran 6			13.50	
D.238	1981-027A	Raduga 8	-375 km	315 km	13.51	
L2.17	1981-049A	GOES 5			9.83	
D.208	1981-057B	APPLE	-25 km	158 km	12.83	1984
L1.34	1981-061A	Ekran 7			13.24	
L1.49	1981-069A	Raduga 9			13.16	
L1.11	1981-102A	Raduga 10			13.04	
D.196	1982-009A	Ekran 8	-30 km	217 km	12.93	1984
D.404	1982-031A	Insat 1A	- 225 km	149 km	0.07	1984
L1.9	1982-044A	Kosmos 1366			12.80	
L1.38	1982-093A	Ekran 9			12.43	
L2.25	1982-103A	Gorizont 6			12.04	
L2.3	1982-105A	RCA Satcom 5			6.35	
L1.10	1983-028A	Raduga 12			11.46	
L2.16	1983-041A	GOES 6			8.78	
D.232	1983-059C	Palapa 3	5 km	50 km	7.01	Failed 1995
		(included here because the orbit is very close to GSO)				
L1.61	1983-089B	Insat 1B			7.54	1993
D.233	1983-098A	Galaxy 2	- 3 km	45 km	4.09	1994
L1.36	1983-100A	Ekran 11			11.73	
L1.14	1984-016A	Raduga 14			10.77	
L1.5	1984-022A	Kosmos 1540			11.76	
L1.7	1984-031A	Kosmos 1546			10.66	
L1.66	1984-035A	China 15			9.43	
L1.24	1984-041A	Gorizont 9			10.50	
L1.59	1984-063A	Raduga 15			10.55	
L2.22	1984-078A	Gorizont 10			10.24	
L3.7	1985-007A	Gorizont 11			9.84	
L2.30	1985-016A	Kosmos 1629			10.02	
L1.71	1985-035B	Telecom 1B			8.78	Failed 1988
D.239	1985-048C	Arabsat 1B	- 83 km	5 km	5.84	
L2.26	1985-070A	Raduga 16			9.60	
L2.14	1985-076C	ASC-1			3.79	
L1.20	1985-102A	Kosmos 1700			9.32	
D.229	1985-107A	Raduga 17	-11 km	75 km	9.37	1992
L1.37	1986-010A	China 18			8.32	
L2.36	1986-027A	Kosmos 1738			9.34	
L1.45	1986-044A	Gorizont 12			8.84	
L3.9	1987-084A	Kosmos 1888			7.74	
L2.31	1987-091A	Kosmos 1894			7.85	
L1.22	1987-096A	Kosmos 1897			7.64	
L2.20	1987-100A	Raduga 21			7.86	
L1.16	1988-014A	China 22 (STTW-1 2)			4.70	
L1.19	1988-063A	INSAT 1C			7.43	

Status	*COSPAR ID*	*Name*	*Perigee*	*Apogee*	*Inclination*	*EOL man*
L1.3	1988-066A	Kosmos 1961			7.04	
L1.62	1988-095A	Raduga 22			6.86	
L1.53	1989-030A	Raduga 23			6.49	
L1.50	1989-081A	Gorizont 19			6.14	
L1.39	1989-098A	Raduga 24			6.06	
L2.35	1989-101A	Kosmos 2054			5.90	
L1.29	1990-011A	China 26 (STTW-2A)			3.09	
L2.23	1990-016A	Raduga 25			5.80	
L1.23	1990-054A	Gorizont 20			5.55	
L1.4	1990-061A	Kosmos 2085			5.47	
L1.27	1990-112A	Raduga 26			5.12	
L1.35	1990-116A	Raduga 1-02			5.12	
L1.6	1991-010A	Kosmos 2133			4.00	
L1.58	1991-014A	Raduga 27			5.29	
L2.3	1991-064A	Kosmos 2155			4.70	
L3.8	1991-079A	Kosmos 2172			4.45	
L2.29	1992-059A	Kosmos 2209			3.91	
L1.64	1992-088A	Kosmos 2224			2.66	
L2.13	1993-077A	Telstar 401			1.99	Failed
L1.40	1994-012A	Raduga 31			2.63	
L2.28	1994-038A	Kosmos 2282			1.53	
L1.2	1994-069A	Elektro			2.42	
D.264	1994-080A	DFH 3 (China 44)	- 572 km	185 km	3.18	Failed to GEO
L2.34	1994-082A	LUCH			1.07	
L2.4	1995-057A	UFO 6 (USA 114)			3.68	
D.305	1997-027B	INSAT 2D	-2620 km	179 km	1.46	Failed 1997
L2.32	1997-041A	Cosmos 2345			0.22	
L1.21	1997-070A	Kupon 1			1.09	Failed 1997
L1.8	1998-025A	Cosmos 2350			1.34	

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Committee on the Peaceful Uses of Outer Space

Note verbale dated 20 January 2000 from the Permanent Mission of Japan (Vienna) addressed to the Secretary-General

In accordance with article 5, paragraph 1 of the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of objects Launched into Outer Space, the Permanent Representative of Japan hereby wishes to notify the Secretary-General that component parts of a space object have been discovered on Japanese territory. The object was found on the beach on Yoron Island in the Kagoshima Prefecture by inhabitants of the island on 8 November 1999. It is a cylinder-shaped object, which is 6m in length and 1.25m in diameter. It is believed to be a component part of a United States launch vehicle. An investigation concluded that the object poses no risk of hazards to people and property, and it is temporarily being kept at the village office on the island. At present, and in cooperation with the Government of the United States, efforts to identify the object are underway.

In accordance with article 5(1) of the 1968 Agreement cited above, the Government of Japan is also notifying the Government of the United States.

The Permanent Mission of Japan further has the honour to request that this communication be circulated to Member States as an official document of the United Nations Committee on the Peaceful Uses of Outer Space.